POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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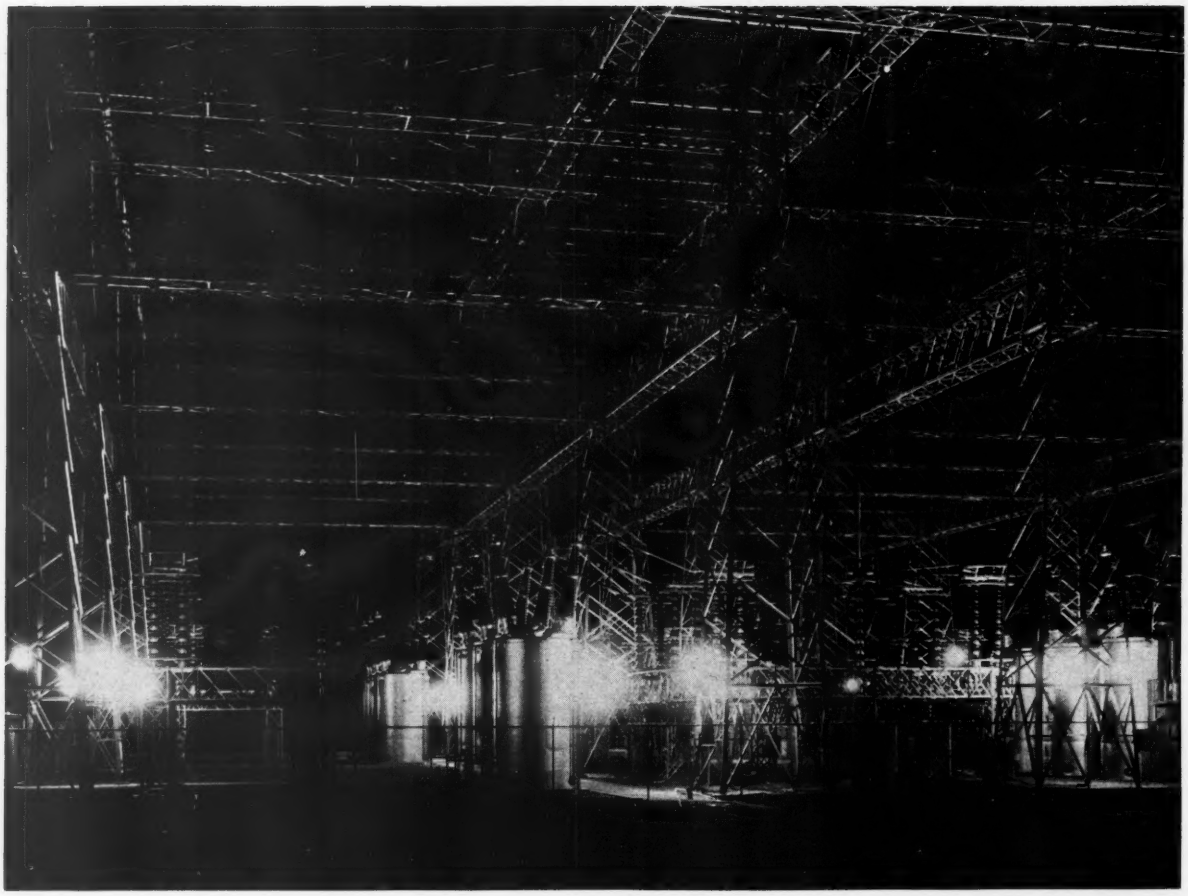


Photo, Bureau of Reclamation

OL' MAN RIVER GOES TO TOWN

TIME WAS when Ol' Man Colorado stepped out he would go on a rampage up and down the Imperial Valley, tearing up dykes and levees, raising his bed, burrowing his way into new courses and striking terror into the hearts of the 75,000 settlers in that fertile valley. Millions of dollars were spent annually in combating these sprees, with some success but always with the fear that the next outbreak would bring disaster. It was a desperate effort to keep the river from pouring its entire flow into the valley. Had man lost, it probably would have been centuries before the Imperial Valley again was dry.

Now all this is history. During the past seven years the great Boulder Dam has been built and with its completion the waters of the Colorado are held permanently in check and the inhabitants of Imperial Valley can attend to the cultivation of their hundred million dollar crop with assurance of perfect safety from floods.

The Colorado, in the meantime, has been taught better ways. It still has an abundance of pep and energy but it has been compelled to direct this energy in a more effective, a more civilized manner. Today the disembodied energy of the mighty Colorado goes to town by way of the structure shown above—over the 287,500 v. transmission system to Los Angeles where it contributes to the comfort, prosperity and happiness of millions of people. Etched against the black desert sky, the steel of the high voltage switching yard at Boulder Dam impressively symbolizes the power of the mighty river whose forces it keeps in check.

WITH THE EDITORS

Implications of a Power Age

ON SOME recent visits to power plants throughout the country one thing particularly impressive was the rapidly accelerating tempo of industrial activity—the speed with which methods and equipment complete their life cycles. In the case of a large automobile plant a power plant built in 1921 with the latest equipment available at that time, was almost completely scrapped and being replaced with new apparatus, turbines, boilers and all; only a vestige of the original plant remained. In another plant, which exemplified the last word in boiler equipment in 1929 when it was built, a new boiler installation was in progress, which was so far ahead of the existing units in terms of economy of operation that the old units will be retained, largely as standbys.

This aspect of engineering may be thought of as a manifestation of the accelerating tempo of our whole civilized life, a consequence of scientific advancement and improvement in the technique of machine production. It is that, of course, but, fundamentally, it is much more than that for in the boiler and turbine we are dealing with the very root of the matter and, more properly, the comparison should be reversed; the accelerating tempo of civilized life, rather, is the consequence of this aspect of power plant engineering.

For, if we study the matter, if we forget for a moment questions of the Supreme Court, sit-down strikes, dictatorships, unbalanced budgets and all the other disturbing elements in the world today which prevent us from thinking very clearly about anything, we will find that this "speed-up" in power production technique is close to the beginning of many of our problems. It is in the modern power plant that we first witness the increased availability of power. Every person connected with the industry knows that, during the last 30 years, the amount of power derived from a pound of coal has increased from 300 to 1000 per cent; that, at the same time, the number of operators needed to release this energy has steadily decreased. Almost every power plant man is familiar with the astonishing spectacle of one operator in complete control of one or more boilers generating hundreds of thousands of pounds of steam per hour. Thirty years ago a score of men could not have shoveled coal into such furnaces fast enough.

The stationary power plant, of course, is only one phase of this increase in the availability of power. The automobile, the airplane, the locomotive, the tractor, the high voltage transmission line, our communication systems are others; all these have made a world entirely different from that of our grandfathers.

Most of our present difficulties can be traced to inability to adjust ourselves to this changed world, an inability to adjust our mental processes, our ideas and philosophies to an energy level of from 25 to 100 horsepower per capita. Fifty years ago, the energy level was only about ½ to 1 hp. per capita. Today, too many people who drive automobiles and use electric refrigerators are mentally still in the horse and buggy era.

This is not an argument for or against any of the questions confronting the American people at the present time; one of the rights of a democracy is the expression of individual opinion. But the same flexibility which characterizes our thinking along technical and engineering lines should extend also to other elements of civilization. As it is, there is a great deal of lop-sided argument at the present time. The same people who, on the one hand, invoke the law to protect their interests are loudest in denunciation of legal methods designed to protect the interests of others.

Recognition is needed that while the world is changing and things move much more rapidly than in the age of our forefathers, fundamental principles of right and justice have not changed. Rather than try to find arguments for preconceived notions, would it not be wise to study these notions impartially and learn to scrap obsolete ideas and prejudices as we do obsolete boilers and turbines?

Power Costs

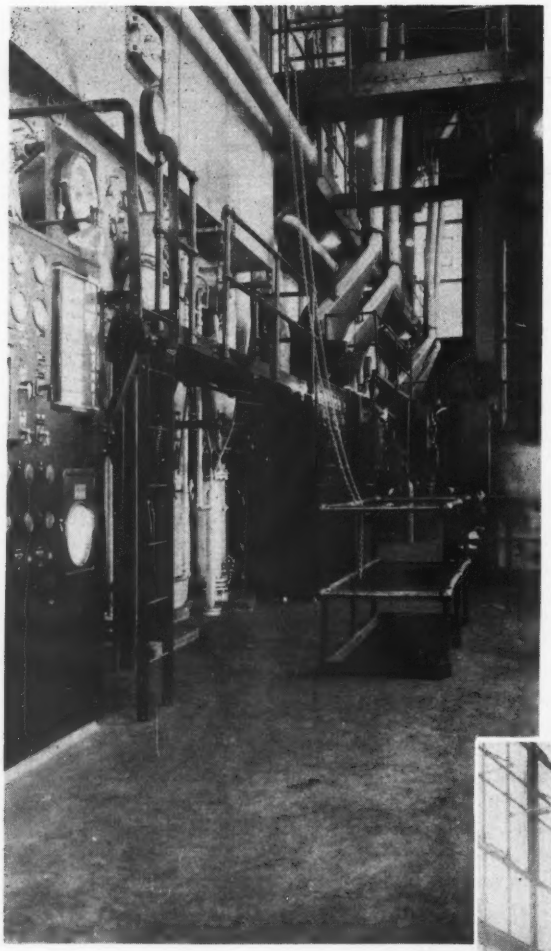
LOW COSTS should not be the ultimate aim of an engineer but the costs should be as low as compatible with the reliability and regulation demanded by the load. As such, the engineer should know his costs in detail so that they may be analyzed to determine the most logical point of attack.

Obviously, it is desirable to have as much as possible of this work done by the accounting department whose primary function it is. If the management is at all sympathetic, a diplomatic engineer should have little difficulty in having accounts set up in such a way that they are of use and service to him as well as to the business end.

In some cases this is not possible and often the breakdown of certain accounts must, if it is to be of service to the engineer, be carried far beyond any legitimate demand of the accounting department. In this case, the engineer's costs and account set-up should agree with that of the accounting department so that in the final analysis they check.

Experience of those interested in industrial plant power costs show that the engineer's cost figures, if they exist at all, are far below those of the accounting department. Few engineers apparently have the complete picture. Without it, how can they make a fair decision between the isolated plant vs. purchased power, or, justify a past decision?

Lynn Gas & Adds



IN A RECENT editorial we discussed briefly the rapidly accelerating tempo of industrial activity—the speed with which methods and equipments complete their life cycles. A case in point we mentioned was the power plant of a certain large automobile factory built in 1921 with the latest equipment available at that time, but which was now being scrapped and replaced with new equipment. In times past machinery installed was expected to live through at least a major part of its useful life, but in these days of rapid technical development machinery is often rendered obsolete after a few years' service by the development of new, more efficient equipment.

FIGS. 1 TO 4

Above is shown a view on the operating floor of the boiler room at the Lynn Plant showing the new pulverized coal unit in the foreground. The main boiler control board is shown at the extreme left. The picture at the right shows two of the three fuel feeders. These receive coal from the coal scales on the floor above and discharge to the pulverizers below. Further to the right is a view in the turbine room showing the 20,000 kw. generating unit and the direct current generating sets. On the opposite page at the extreme right is a view of the new boiler room electrical switchboard

Electric Co. Pulverized Fuel Boiler Unit

This phase of modern industrial life is well illustrated in the plant considered in this article. In 1928 and 1929, when the Lynn Gas & Electric Co. built their Broad street plant, it contained the last word in boiler and turbine equipment. The 1582 hp. boilers, with their highly developed underfeed stokers, represented the best that money could buy and their output of 200,000 lb. of steam per hr. at 400 per cent rating was in accordance with the best practice of the times. There were two such units, delivering steam at 400 lb. pressure to a 21,500 kw. turbine-generator unit.

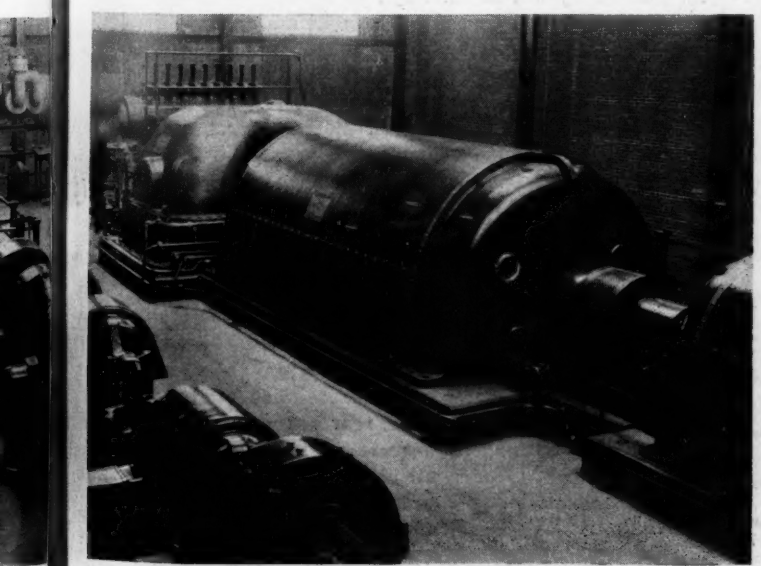
During the past year, however, a new boiler installation has been made in this station which in terms of economy of operation is so far ahead of the old units that the latter will be retained largely as stand-by units. The old units are still in perfect operating condition and they will be retained as part of the "active" station equipment, but whenever possible the new unit will carry the major part of the steam load. This state of affairs is no reflection on the part of the designers of the station nor the manufacturers, it is merely an illustration of a characteristic of the age in which we live. Nor must it be thought that the old equipment is inefficient; it is not, but its efficiency is somewhat less than that of the new unit and at the high outputs at which steam equipment is operated these days, even a few per cent more or less often amounts to a considerable saving or loss. Another advantage of the new boiler unit is the fact that it can burn a cheaper grade of coal.

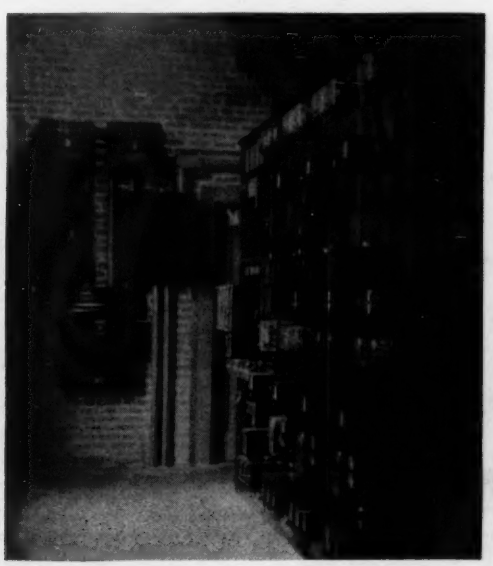
The new steam generating unit is installed in the same building as the old units in the space reserved for a future unit when the plant was built. It is a Riley unit, with a rating of 208,000 lb. of steam per hr. at 430 lb. gage and a total temperature of 775 deg. F. The turbine is designed for only 700 deg., but the manufacturers have advised that the temperature could be raised to 750 deg., in fact, on short swings, even slightly greater. Since it is estimated that there is a gain of about 1 per cent in the water rate for each 12 deg. increase in steam temperature, this 50 deg. increase in temperature will result in an over-all gain of about 4 per cent in the steam consumption.

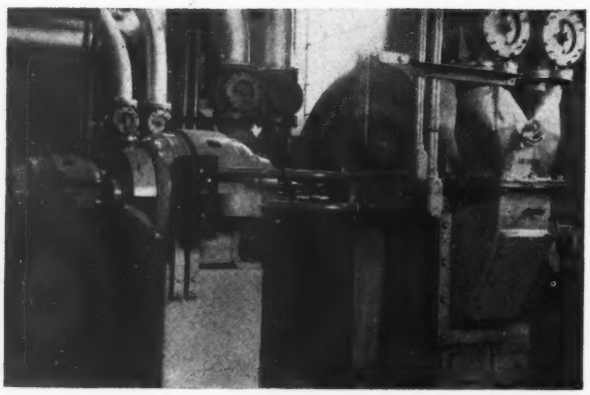
It is planned at some future time that additional superheating surface will be installed in the boiler to bring the temperature up to 810 deg. F. In time, the amount of superheat on the old boilers may also be raised.

The steam generating unit consists of a boiler, superheater, desuperheater with control, water-cooled furnace, steel clad insulated setting, pulverizers, burners, air preheaters, forced and induced draft fans and fly ash precipitator, together with the feedwater and coal handling equipment necessary.

The arrangement is simple and direct and is clearly illustrated in the accompanying elevations, Fig. 8. The







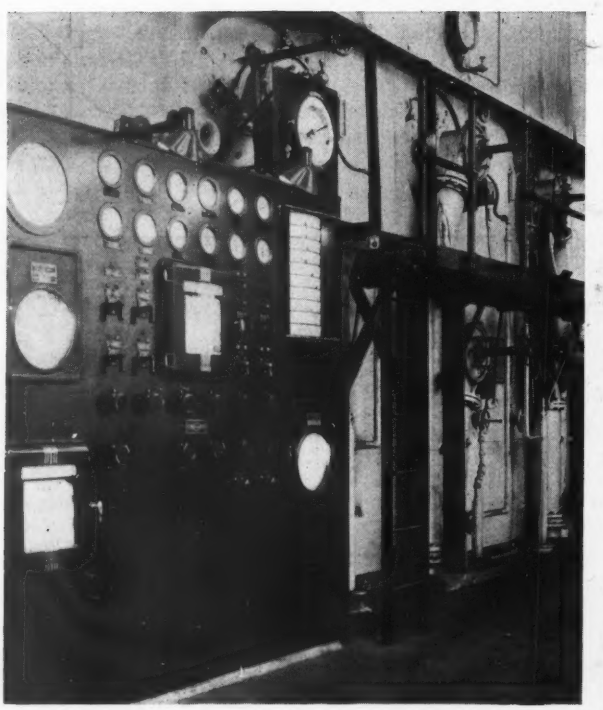


Fig. 5 (Top). One of the pulverizing mills. Fig. 6 (Center). A view from the boiler house of the conveyor system for handling coal. Fig. 7 (Bottom). The main combustion control and boiler meter panel

boiler and furnace occupy approximately four floors. The pulverizers are installed in the basement or the grade level floor with the coal feeders directly above on the operating floor. The induced draft fan is on the upper floor directly underneath the fly ash precipitator, which is a Cottrell electrostatic unit.

Raw coal is stored in steel overhead bunkers, as shown and delivered to three all-enclosed Richardson electrically operated automatic weigh scales, mounted on a grating above the operating floor. These in turn discharge directly into the feeders through vertical pipes, and the feeders, under the control of the automatic combustion control system, feed the coal to the pulverizing mills below. The boiler has six circular flare type burners installed in three pairs of two each, one directly above the other in the front wall of the furnace. Each pair of burners is supplied by one of the three pulverizers. The latter are No. 5 Riley Atrita mills with a maximum rated output of 11,000 lb. of coal per hour. Two pulverizers in combination with four burners can deliver the rated boiler output.

Forced draft is supplied by a Sturtevant fan capable of delivering 310,000 lb. of air per hr., driven by a General Electric wound rotor induction motor with a speed range of 2-1. The air delivered by this fan is heated by one or two Ljungstrom air preheaters, each having 7900 sq. ft. of heating surface. One of these heaters is used for air temperatures of 271 deg. F. or lower, while two are used for air temperatures of 305 deg. F. and above.

From the air preheater, the gases are drawn through the electrostatic precipitator by the induced draft fan and then delivered to the stack. The induced draft fan is a Sturtevant fan with a rated capacity of 340,000 lb. of gas per hr. Like the forced draft fan, the induced draft fan is also driven by a 2-1 speed range wound-rotor induction motor.

The electrostatic precipitator as shown is mounted on the roof of the boiler house. It is a Cottrell, rod-curtain type unit consisting of two elements having a combined rating of 95,600 cu. ft. of gas per min. with a gas temperature of 356 deg. F. at the inlet. The precipitated fly ash is delivered to a hopper external to the boiler house by means of a vacuum air transport system. The precipitator elements are supplied with direct current at a potential of as high as 75,000 v. by means of mechanical, synchronous rectifiers. The step-up transformers, rectifiers and associated control apparatus is all located on the upper floor of the boiler house close to the forced and induced draft fans.

A radial brick stack is mounted on the steel structure of the building. This is a Custodis perforated brick stack 12 ft. inside diameter at the top and 74 ft. 6 in. high above the foundation. The top of the chimney is approximately 170 ft. above ground level.

So much for the general arrangement. The constructional features are quite evident from the drawing and need no particular comment. The electrical bay on the operating floor at the rear of the boiler contains the 575 v., 3 phase, 60 cycle extension to the existing switchboard for controlling the motor driven auxiliaries. This board consists of steel cubicles with removable truck type air circuit breakers.

This new boiler is always operated in conjunction

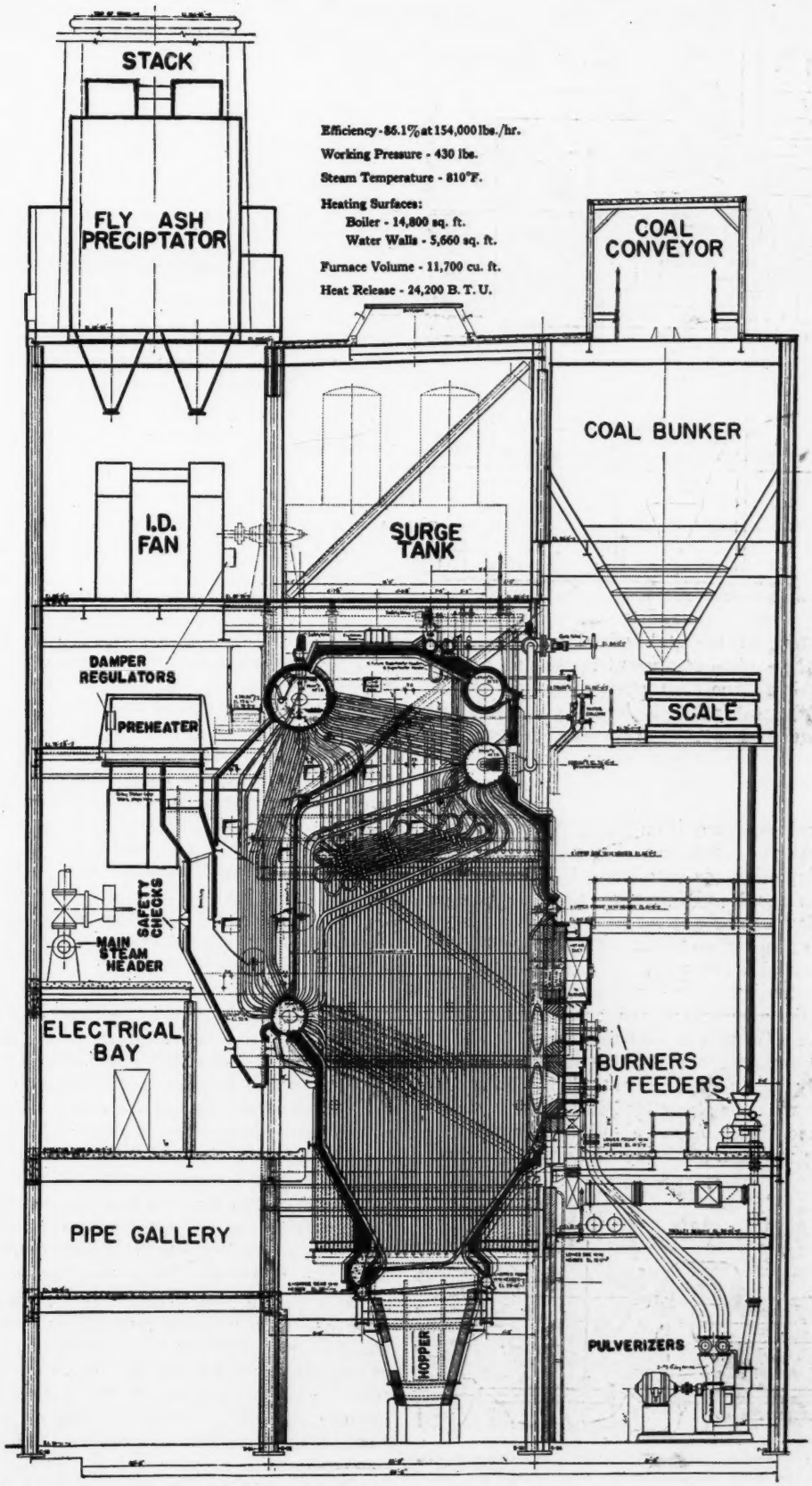


Fig. 8. Section showing the arrangement of the steam generating unit in the station

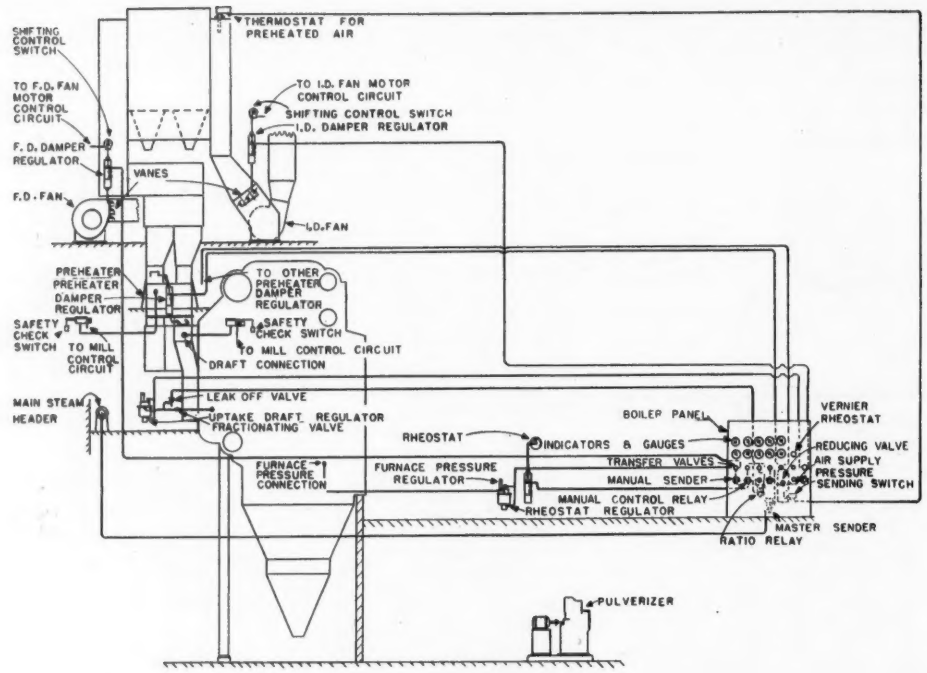


Fig. 9. Combustion control layout for the new unit

with at least one of the stoker-fired units. At the present time, the control equipment for this new boiler (Unit No. 3) is independent of the existing control equipment on the stoker fired boilers (Units Nos. 1 and 2). The control system is so arranged, however, that in the near future it will be possible to govern all of the boilers from the "master sender" of boiler No. 3 by the addition of a pneumatic-electric impulse sender.

The control equipment on Unit No. 3 operates properly with its own master sender with boilers Nos. 1 and 2 carrying minimum base load. Under these conditions, boilers Nos. 1 and 2 operate semi-automatically with the Bailey master controller for these units out of service. At times when boiler No. 3 is out of service, boilers Nos. 1 and 2 are operated automatically from the Bailey master controller for these units.

A schematic diagram of the combustion control system for the new unit is shown in Fig. 9. Fundamentally, the system operates automatically to adjust simultaneously and in a definite ratio both fuel and air in accordance with the steam load and to maintain the desired furnace draft. Air at about 75 lb. pressure is the operating medium. The actual impulse pressures vary from about 10 lb. at maximum boiler rating to 50 lb. at minimum rating. This inverse relationship between boiler rating and impulse pressure is used to guard against loss of plant load in case the air pressure fails through breakage of the air lines or failure of power to the compressor. In this event, the rating is gradually increased as the pressure falls in the compressed air system, and while the safety valves may pop if the boilers are not transferred to normal control, there is no danger of dropping the load.

As will be seen from the diagram, steam pressure from the header acts on the master sender which controls the impulse pressure on the system. This impulse pressure acting through the panel relays controls the power elements of the system.

The fuel supply to the boiler is varied as required by variation in the speed of the feeders whether one, two, or three feeders are in use. Simultaneously with changes in the fuel supply, the air supply to the furnace is adjusted by varying the setting of the induced draft fan inlet dampers and also by changing the speed of the fan when necessary. The induced draft fan is of the double inlet type with dampers in each inlet which are linked together.

Similarly, the forced draft fan outlet damper setting is varied and the speed of the fan changed as required to maintain the correct furnace draft.

It is not our purpose to describe all the details of this combustion control system here since that has been done elsewhere,[1] but a few of the general features which characterize this system may be of interest. All of the adjustments mentioned above are of course controlled and coordinated by the control system. The impulse pressure developed by the master sender becomes the master impulse which acts through an "auto-

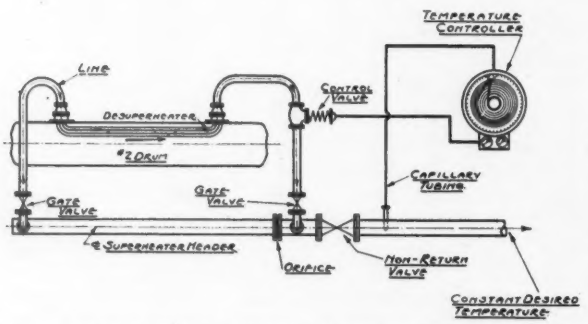


Fig. 10. Schematic piping arrangement for constant steam temperature control

[1]For a complete description of the Hagan Combustion Control System, see p. 161, March 1936, number of POWER PLANT ENGINEERING.

List of Principal Equipment in the Pulverized Fuel Burning Addition at the Lynn Gas & Electric Co.

General

Owners—Lynn Gas and Electric Co.
Location—Lynn, Massachusetts.
Engineers—Stone & Webster Engineering Corporation, Boston, Mass.
Electric Generating Capacity—40,000 kw.

New Steam Generating Unit

Complete steam generating unit, consisting of a boiler, superheater, de-superheater, water cooled furnace, air pre-heater, pulverizers and steel clad setting, together with forced and induced draft equipment, coal and ash handling equipment, feed water system and control apparatus.

Boiler, furnace and setting. Riley Stoker Corp.

Capacity—present installation, 208,000 lb. steam (actual) per hr., with 430 lb. gage at superheater outlet and temperature 775 deg. F.
Future installation, 205,000 lb. steam (actual) per hr. with additional superheating to 810 deg. F., pressure 430 lb. gage.
Boiler feed temperature, 275 deg.
Boiler heating surface, 14,800 sq. ft.

Furnace—Volume 11,700 cu. ft. Water wall heating surface, 5660 sq. ft. Heat liberation 24,200 B.t.u. per cu. ft. per hr.

Superheater, (Riley) Type Radiant and Convection. Surface 2960 sq. ft. (ultimate). Location, Interdeck.

Superheat Control

Superheater outlet steam temperature is maintained constant from 50—100 per cent rated output by means of submerged tube type desuperheater located in boiler drum No. 2.

Boiler and Setting

Type 4—drum continuous flow (Riley).
Pressure—430 lb. per sq. ga. at superheater outlet.
Tube Arrangement—Bent tube.
Baffling—across the tube.
Height of dry steam drum above firing floor—40 ft.
Width setting between side walls—22 ft.

Firing

Ignition—Electrically lighted illuminating gas—starting sequence.
Fuel—Pulverized coal.
Burners—Riley No. 3 circular flare type (suitable for coal or oil).

Pulverizing Equipment.

Type—Riley No. 5 B Atrita Mills.
Quantity—3 mills—each mill rated output
3,000 lb. coal per hr. (minimum)
13,000 lb. coal per hr. (maximum).
Degree of pulverization—(low volatile coals).
Fineness, per cent through 200 mesh screen—77.5 per cent.
Fineness, per cent through 50 mesh screen—98.9 per cent.
Power input to mill—70.5 kw. (at 13,000 lb. coal per hr.)
Each pulverizer supplies two burners. Two pulverizers in combination with four burners can deliver rated boiler output.

Ash Elimination—Research Corporation

1. Fly Ash
   (a) Precipitated from flue gases by means of rod-curtain type Cottrell electrostatic precipitator of two units. Rating—95,000 cu. ft. gas per min., with temperature of gas to inlet, 356 deg. F.
   (b) Removed to hopper external to boiler house by means of vacuum air transport.
2. Pit Refuse (Ash, etc).
   Removed to hopper external to yard by means of salt water pumping.

Ash Hoppers and Storage Hoppers—Allen-Sherman-Hoff.

1. Fly Ash—Dry Storage—40 t. tank.
2. Furnace Ash—20 t.—dehydrating type tank.

Coal Scales—Richardson Scale Co.

3—Type totally-enclosed. Capacity 12 tons per hour.

Comustion Control—Hagan Corporation.

Type—Hagan Air Pressure.
Air Pressure furnished by 2—2 stage 5 hp. compressors.

Fans

A. Induced draft (1) B. F. Sturtevant Co.
   1. Rating—340,000 lb. products of combustion per hr.
   2. Drive—wound rotor induction motor.
   3. Speed range—2-1 (865 r.p.m. F.L.)
B. Forced draft (1) B. F. Sturtevant Co.
   1. Rating—310,000 lb. air per hr. Air at 80 deg. F.
   2. Drive—wound rotor induction motor.
   3. Speed range—2-1 (1165 r.p.m. F.L.)

Air Preheaters—Air Preheater Corporation.

Type—2 Ljungstrom heaters.
Operation—one in service for gas temperatures of or below 271 deg. F. leaving preheaters—two in service for 305 deg. F. and above.
Heating surface—Approximately 7900 sq. ft. each.
Performance (Typical Actual Preheater)

Boiler output	156,000
Temperature steam	775 deg. F.
Temperature flue gas in	621 deg. F.
Temperature flue gas out	315 deg. F.
Temperature air in	80 deg. F.
Temperature air out	431 deg. F.

Draft and Pressure Indicating Gages

Flush Type—Republic Flow Meters Co.
Boiler Flow Meter
Steam Flow—Air Flow—Bailey Meter Co.
Flue Gas Analysis
Carbon Dioxide combination.
Indicating and Recording—Leeds & Northrup Co.

Chimney—Alphons Custodis Chimney.

Superimposed perforated radial brick 12 ft. inside—diameter at top—74 ft. 6 in. high above foundation. Top of chimney approximately 170 ft. above ground level.

Electrical Equipment

575 v., 3 phase, 60 cycle switchboard extension to existing switchboard. Enclosed—steel cubicle type with removable truck-type air circuit breakers. I-T-E Circuit Breaker Co.

Feed Water System—Nothing new added.

Feed Water Treatment—Hall Laboratories.

Insulation—All insulation on boiler, furnace and piping by The Phillip Carey Co.

Miscellaneous

Soot blowers—The Bayer Co.
Gage columns—Diamond Power Specialty Co.
Blow-off valves—Yarnall-Waring Co.
Stop valves—Chapman Valve Mfg. Co.
Non-return valves—Wm. Powell Co.
Safety valves—Crosby Steam Gage & Valve Co.
Feed water Controllers—The Stets Co.
Excess feed water pressure Regulators—Copes—Northern Equipment Co.
Majority of valves—Chapman Valve Mfg. Co.
Deaerating heater—Cochrane Corp.
Motor-generator set D.C. supply for Coal Feeder Motors—Westinghouse Electric & Mfg. Co.

matic-manual'' transfer valve and master control compensating relays to generate impulse pressures for the air flow regulators. The transfer valves which are mounted on the main boiler control panel provide a quick means for shifting from automatic to manual control, and the manual control relay allows manual control of all boilers (if there are other boilers) as a unit. Indicating gages on the master panel at all times show the impulse generated by the master sender and the impulse transmitted by the master control relay to the individual boiler panels.

The water supply for the new boiler is obtained from the Lynn City water system. This is evaporated and treated by the Hall method, using trisodium phosphate.

An interesting feature of the boiler is the method of controlling the temperature of the steam to the turbine. This is done automatically by means of a thermostat in the main steam line as shown in Fig. 10. This thermostat operates to open or close a control valve in an integral desuperheater line in the drum No. 2 of the boiler. As will be seen, the superheated steam line connects into the main steam line through an orifice. On the superheater side of this orifice is a by-pass which leads to a set of coils submerged in drum No. 2, so that the steam passing through these coils is

Test data on new unit

Test No. 1
Date Nov. 12, 1936
Plant of Lynn Gas & Electric Co. Location Lynn, Mass.
Conducted by H. S. Spaulding Test Duration 10 Hours
Boiler-Make & Type Riley YPR-374W.W. Rated Cap. 208,000#/hr.
Ht. Surf. Sq.Ft. Boiler 14995 W.Walls 5900
" " " " Super. 3120 Air Heater Ljungstrom Furn.Vol.Cu.Ft. 11700
Pulverizer-Type & Size 3-#5B Single Burner-Type & Size 6 #3 F.T.

PRESSURES & TEMPERATURES		
Steam Press. Boiler Drum	Lbs.Ga.	431.6
" " Superheater Exit	" "	403.2
" Temp. at	°F.	727.41
Superheat °F.		278.5
Temp. Wt. Ent. Boiler	"	294.34
Feedwater Pressure	Lbs.Ga.	450.0
Temp. gases leaving boiler	°F.	647.6
" " " air heater	"	335.2
" air entering " "	"	108.2
" " leaving " "	"	473.2
Press. Air Ent. Air Heater	In. W.	7.37
" at Burner	"	4.54
Draft in Furnace	"	.117
" at Boiler Outlet	"	.92
" " Air Heater Outlet		1.3

TOTAL QUANTITIES		
Wt. of Fuel Fired	Lbs.	125,400
Actual Evaporation	"	1,447,500
Equiv.Evap. F.& A. 212°F.	"	1,660,282
Weight of Blow-Down	"	None
Total Equiv.Evap. F. & A. 212°	"	1,660,282
Factor of Evaporation		1.147

HOURLY QUANTITIES		
Wt. of Fuel as Fired	Lbs.	12,540
" " " Dry	"	12,139
BTU Release/cu.ft. Furn.Vol./hr.		15,200
Total Equiv.Evap. F. & A. 212°	"	166,028
% Rated Cap. Developed		67
Equiv.Evap./lb. dry fuel	"	13.68
EFF. OF STEAM GEN. UNIT	%	90.8

FUEL DATA			
Prox.Analysis	As Fired	Dry C	
Moisture %	3.2		
Vol.Matter %	19.9	20.5	21.9
Fixed Carbon%	70.5	72.9	78.1
Ash %	6.4	6.6	
Total	100.0	100.0	100.0
BTU per lb.	14,140	14,610	
Sulphur (Sep. Det.)	0.5	0.6	

ULTIMATE ANALYSIS (DRY)		
Carbon	%	88.8
Hydrogen	%	4.63
Oxygen	%	4.0
Nitrogen	%	1.37
Sulphur	%	0.6
Ash	%	6.6
		100.0

FLUE GAS ANALYSIS Taken at Boiler Outlet		
CO2	%	15.68
O2	%	2.56
CO	%	0.00
NE By Dif.		81.76

HEAT BALANCE			
Heat Absorbed--	BTU	%	
By Boiler & Super.)			
" Air Heater)	13,273	90.8	
Heat Loss Due to-		#	
Moist. in Fuel	37	.25	
Hydrogen	468	3.21	
Moist. in Air	17	.12	
Dry Chimney Gas	726	5.01	
Comb. in Refuse	321	2.2	
Rad. & unacc't.	- 232	-1.59	
		100.	

desuperheated by the water in the drum. The amount of steam thus bypassed is controlled by the control valve as a function of the temperature in the main steam line. By means of this submerged tube desuperheater the outlet steam temperature is maintained constant from 50 to 100 per cent output. There is also another desuperheater in the main line to the turbine for additional control of the steam temperature. Since this new boiler is always operated in conjunction with at least one of the stoker fired boilers, which operate at a lower steam temperature, this in itself tempers the steam to the turbine.

As explained previously, one of the advantages of this new steam generating unit over the stoker fired boilers is its ability to burn a cheaper grade fuel. In general this amounts to about 20 to 22 cents per ton. Since its completion in the latter part of 1936 it has operated satisfactorily and with the full economy expected of it. On tests even at partial loads, the efficiency obtained was over 90 per cent. Data on one of these tests is shown in the accompanying tabulation.

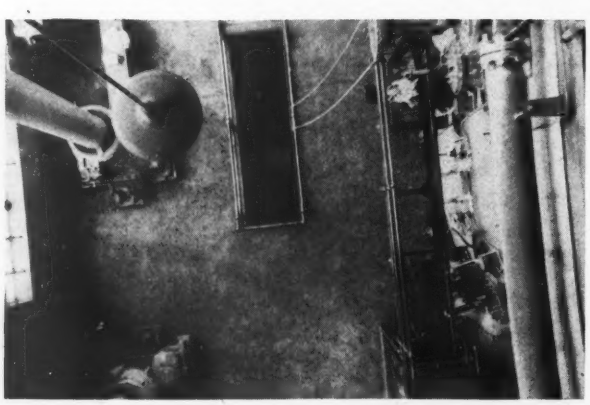


Fig. 11. A view from the top looking straight down on the operating floor

This particular test, as will be noted, was at 67 per cent of full load rating and the overall efficiency was 90.8 per cent.

In conclusion, a few words about the turbine equipment may be of interest. This, as pointed out, was installed in 1929 when the station was first built and consists of a General Electric Curtis turbine operating at 400 lb. pressure, direct connected to a 20,000 kw. 0.8 power factor, 3 phase, 60 cycle, 13,800 v. generator with a 1500 kw., 550 v., 3 phase, 60 cycle house service generator, a 35 kw. primary exciter and a 2 kw. pilot exciter, all on the same shaft.

Direct current is generated by two small generating units, one a 300 hp. motor driven unit and the other a dual driven unit driven either by a turbine or a 200 hp. induction motor.

The new installation, as well as the original plant, was designed and built by Stone and Webster, Inc., of Boston. It is located on tide water and salt water is used for condensing purposes. Fuel is delivered to the station by 6000 to 7000 ton steamers.

In closing we wish to extend our indebtedness to the engineers of the Lynn Gas & Electric Co. for their cooperation and assistance in making this description possible.

Record Gas Demand in Northern California

GAS CONSUMPTION throughout Northern and Central California broke all records in January—the coldest January in 66 yr., according to the Pacific Gas & Electric Co.

In San Francisco the requirements for heating homes and other buildings increased as much at 84.7 per cent over January, 1936, which was the warmest January in 56 yr. In the East Bay cities the increase was as much as 75 per cent. There were similar increases in other sections—as much as 75 per cent in the North Bay counties, 67.7 per cent in Sacramento and environs, 57.2 in the Stockton region, 68.8 per cent in the San Jose district, 84.7 per cent in the Salinas Monterey area.

Consumption in all Pacific Gas & Electric Co. natural gas territory during January totaled more than six and a half billion cubic feet, compared to slightly more than five billion cubic feet in January, 1936.

The greatest single day's consumption throughout the P. G. & E. system amounted to 233,841,000 cu. ft. on January 7, an increase of more than 50,000,000 cu. ft. over the "high" for January, 1936. San Francisco's record was 81,275,000 cu. ft. on New Year's Day, a gain of 10,000,000 cu. ft. over the city's top figures in 1936.

ADAPTABILITY of stainless steel for laboratory equipment is well illustrated in the Ford Motor Company's laboratory at Dearborn, Mich. A large majority of work tables and benches are made of stainless steel, while furnace hoods and stands are shrouded in this non-tarnishing metal. The decorative motif is a band of stainless steel around the walls just above the fixtures. Stainless steel is particularly adapted to this type of service because it is so resistant to many acids and acid fumes.—Electromet Review.

E. E. I. CONVENTION

Chicago prepared to receive representatives of Utility Industry at fifth Annual Convention June 1 to 4

RIDING on a wave of unparalleled activity, which blots out the dark days of the depression and even dims the spectre of government interference, members of the Edison Electric Institute are converging on Chicago for the Fifth Annual Convention. Ominous threats beclouding the first annual convention five years ago in Chicago have disappeared, the grim determination, at Atlantic City 2 yr. ago, to die fighting with backs to the wall, increased morale, and, load conditions envisioned last year at St. Louis have materialized, so that the meeting promises to be the best in the history of the Institute.

Chicago is celebrating One Hundred Years of existence as a chartered city, and the Commonwealth Edison Co. is celebrating its Golden Anniversary, but these evidences of longevity will not dim the enthusiasm of the E. E. I., for its own Fifth Anniversary, for there is a long and prosperous outlook for public service ahead.

Business Sessions

All activities will center at the Palmer House with five business sessions in 4 da., but, the severe business program of former years will be alleviated somewhat by two innovations, the President's Reception on the first evening and a Convention Banquet on the third. Registration for the convention will open at 10:30 a. m., Tuesday, June 1; at 8:30 a. m. on Wednesday; and 9 a. m. Thursday and Friday. The first business session will open at 2:30 p. m. in the Grand Ballroom of the Palmer House, Tuesday, June 1; the second, at 9:30 a. m., Wednesday; the third, at 2:30 p. m., Wednesday; and fourth, at 9:30 a. m. Thursday; and the final session at the same hour Friday morning.

While sales promotion will be the dominating theme of the convention, with the first session given over entirely to the commercial opportunities of the industry, the program as a whole will be well diversified. Subjects relating to merchandising, that will be discussed by authorities in their fields, include air conditioning, kitchen planning in the new building boom, off-peak water heating, better light—better sight, winning the public through sales efforts, appliance servicing costs, new products and new developments in equipment and appliances, the manufacturer's stake in the utility business and rural electrification.

Some of the other addresses will deal with experiences with interconnection; opportunities for young men in the utility business; accident prevention; lawmaking by commissions and government and business. Of particular interest will be a discussion by Dean John T. Madden of New York University of the special study of the public utility industry that he and his associate, Dr. Herbert B. Dorau, have been making during the past 2 yr. The results of this study are being published in a set of six volumes. Awards for the winners of the several Prize Awards administered by the Institute will also be made at the convention.

A partial list of the speakers includes President Kellogg, Messrs. E. J. Doyle, Commonwealth Edison Co.; Philip Sporn, American Gas & Elec. Co.; C. E. Wilson, General Electric Co.; N. G. Symonds, Westinghouse E. & M. Co.; E. T. Gushee, The Detroit Edison Co.; Bernard F. Weadock, Edison Electric Institute; R. E. Fisher, Pacific Gas & Elec. Co.; Dr. L. W. Chubb, Westinghouse E. & M. Co.; William E. Mitchell, Georgia Power Co.; W. C. Mullendore, Southern California Edison Co., Ltd.; D. E. Karn, Consumers Power Co.; Dr. Gus Dyer, University of Tennessee; R. C. Muir, General Electric Co.; and Frank W. Smith, Consolidated Edison Co.

Social

As usual, special entertainment will be provided for the ladies, but, those ladies who prefer to find their own entertainment and delegates who feel the need of relaxation from the arduous demands of convention business, will find it an interesting city in which to enjoy themselves. The Art Institute, Adler Planetarium, Field Museum of Natural History, Shedd Aquarium, Brookfield Zoo, Chicago Historical Museum, Museum of Science and Industry and the Oriental Institute at the University of Chicago are of special interest.

The Chicago Lighting Institute on the 36th floor of the 20 N. Wacker drive Building is a show-place with scores of displays depicting the latest developments in lighting—for the home, industrial plants, stores and offices. One of its headline features is a

six-room model bungalow, equipped with the newest time and labor-saving appliances and lighting equipment.

Delegates are also invited to visit the headquarters of the Electric Association of Chicago and the Electric Club of Chicago at the same address. The Electric Association, organized in 1925, is the medium through which companies engage in the electrical industry in the Chicago district cooperative in promoting the use of electrical services, appliances and equipment. Its activities embrace six divisions, architects' service, lighting and wiring, electrical maintenance engineers, women's, general industry, and members' service.

There are more than 200 golf courses in the Chicago metropolitan district, and the city's theaters and night clubs are among the finest. Points of interest to be visited vary from the famous Buckingham fountain, a symphony of water and colored light, and the bizarre foreign quarters of Chinatown and the Ghetto, to the Union Stock Yards and hundreds of large industrial plants.

Chicago's rise to its position as fourth largest city in the world has been so rapid that it is difficult to believe that only a century ago it was an obscure frontier trading post. Electricity has played an important role in this growth and progress, and Chicago, in turn, has made vital contributions to electrical development.

Chicago's two great world's fairs, the Columbian Exposition of 1893 and A Century of Progress Exposition of 1933-1934, both provided a tremendous impetus to electrical advancement. Twenty million people visited the beautiful "White City" on Chicago's south side in 1893 and marveled at the "most spectacular lighting display ever achieved."

At A Century of Progress exposition 40 years later, Chicago's front yard was a panorama of spectacular and colorful illumination, and hundreds of exhibits portrayed the myriad new uses of electricity for approximately 40,000,000 fair-goers, again accelerating the pace of electrical advancement.

Chicago's location at the crossroads of the nation and its proximity both to sources of supply and markets has made it the home of a wide variety of products. Makers of electric appliances and lighting equipment rank high on its list of manufacturers. Many of the country's best known electrical products are made in Chicago plants.

Many of the technical advances which have blazed the trail for the entire electrical industry have originated in Chicago. Shortly before the turn of the century, the Chicago Edison Co., principal predecessor

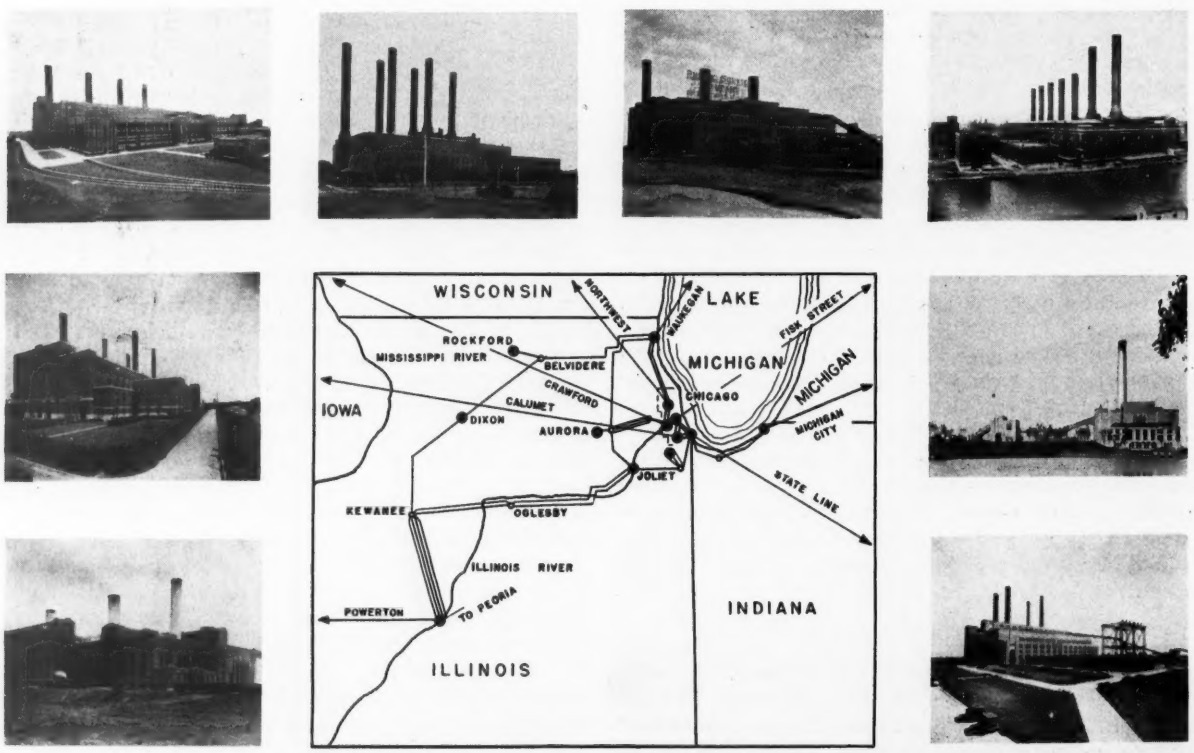


Fig. 1. Chicago is circled by famous generating stations and for half a century has been a bright star in the power firmament. In 1903, the 5000 kw. unit for Fisk St. station set the world thinking that, after all, there might be possibilities of the steam turbine actually being practical. Ten years later 20,000 kw. vertical units at Northwest were an event but vertical turbines were on the decline and another few years saw the ante boosted to 30,000 kw. in horizontal units at Calumet. In 1924 the world knew that the turbine had reached its ultimate development in the 50,000 kw. units at Crawford but another five years and the 200,000 kw. unit at State Line blew the lid off and made the sky the limit. Powerton, Waukegan, Crawford and State Line all played an important part in the development of the reheat cycle, largely instrumental in bringing the heat rate down to around the 13,000 mark in the days before 900 deg. F. steam. Michigan City, the newest station, has a heat rate of around 13,300 B.t.u. per kw. without reheat. Powerton belongs to the Super Power Co. of Illinois, Michigan City, to the Northern Indiana Public Service Co., Waukegan to the Public Service Co. of Northern Illinois, State Line, to the Chicago District Generating Co. and the other four stations to Commonwealth Edison Co. All eight stations were designed by Sargent & Lundy, Inc.,

of the Commonwealth Edison Co. of today, was a pioneer in the long-distance transmission of alternating current at high voltage.

This year is the 50th Anniversary of Edison service in Chicago. The first plant, the Adams Street Station, shown by Fig. 2, was in a three story building at 139 W. Adams Street where the Field Building now stands. In addition to the power plant the building housed the Company's general offices, store rooms and service headquarters. The eight direct-current Edison bipolar generators were belt-driven by small reciprocating steam engines located on the floor below and had an initial combined capacity of only 640 kw. Construction work started in 1887 and the plant was placed in service in August, 1888.

It was also at the Company's Fisk Station, in 1903, that the feasibility of the steam turbine as a means of large-scale generation of electricity at low cost was established. In addition to Fisk Street, the Commonwealth Edison Co. has three other generating stations in Chicago, Crawford, Northwest, and Calumet. Crawford, the largest of these, has a capacity of 377,500 kw.

Fisk Street Station, located on South Fisk Street, and on the south branch of the Chicago river, is the oldest. The first 5000 kw. turbine was installed in 1903 and this was immediately followed by two others; in 1905 by a larger turbine having an ultimate capacity of about 7500 kw. The original units were each supplied with steam from a row of eight Babcock & Wilcox boilers fired with natural-draft chain grates. Beginning with 1906, six larger turbines were installed, with an ultimate capacity of 12,000 kw. each, but served by the same number of boilers with the same size grates. In 1908 and 1909 the first four units were removed and replaced with 12,000 kw. vertical units. Steam pressure is 200 lb. and the temperature 510 deg. F.

In 1914 one 20,000 and one 25,000 kw. horizontal units were put into service. These were followed later in 1919 by a 35,000 kw. and a 30,000 kw. unit. Sixteen larger boilers, equipped with chain grates and with economizers, supplied steam to the four large units. Steam pressure is 220 lb. and the temperature 550 deg. F. A high pressure top unit is now being added. This is a new 30,000 kw. turbine-generator which will operate at 1200 lb. steam pressure. Its exhaust steam, at about 250 lb. pressure, will be used to operate two existing units with a combined capacity of 60,000 kw.

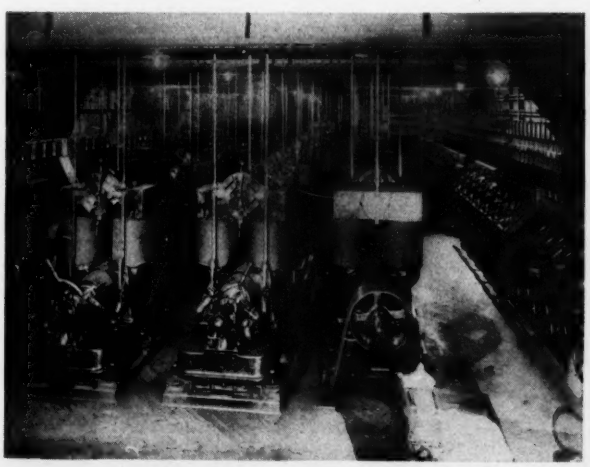


Fig. 2. Fifty years ago this station, located in downtown Chicago where the Field Bldg. now stands, carried the Chicago load. The eight bipolar d.c. generators had a total capacity of about 640 kw. and were belt driven from steam engines on the floor below

Northwest Station was started in 1912 and is located at Roscoe Street and North California Avenue on the north branch of the Chicago River and at the north end of the city. The first two units installed were 20,000 kw. vertical units, followed later by a 35,000 kw. and a 30,000 kw., 25 cycle horizontal units and later by two 30,000 kw., 60 cycle units. One of the vertical units is 60 cycle and the other 25 cycle. Boilers in this station are fired with chain grates, some of them equipped with forced draft. The newer boilers are equipped with economizers. Steam pressure is 250 lb. and the temperature 600 deg. F.

Calumet Station was put into operation in 1921 and is located on the Calumet River at East 100th Street, in the southeast section of the city. It consists of six turbine units and twenty boilers. Five of the turbine units are of 30,000 kw. capacity and the sixth 37,500 kw. Eighteen of the boilers are fired with forced-draft chain grates and are equipped with economizers and air preheaters. Steam pressure is 325 lb. and the temperature 650 deg. F. There are two special boilers which were installed to try out pulverized coal firing. For the past two or three years this station was shut down, except for intermittent operation in cases of emergency, but it was put into regular operation December 1935. Three of the boilers were fitted for burning natural gas and the station operates on dump gas except in the extremely cold weather, when it is necessary to revert to coal because gas is not available. Station performance is about 18,000 B.t.u. per net kilowatt-hour.

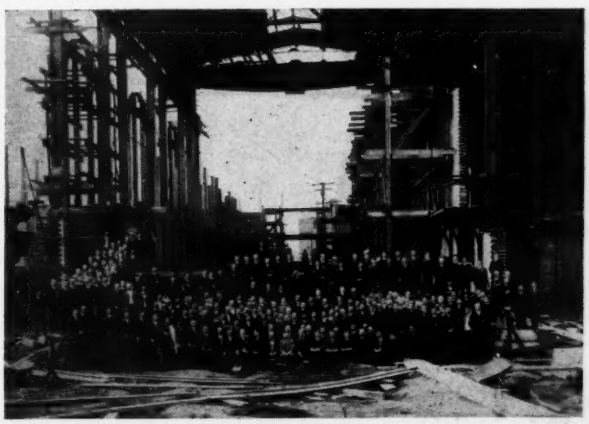


Fig. 3. In 1903, the N.E.L.A. Convention, meeting in Chicago, went out to Fisk Street Station probably to discuss the monster 5000 k.w. vertical turbine which was being installed. This year Fisk Street will attract many of the E.E.I. convention delegates because Fisk St. is being rejuvenated by a new high pressure top, all mixed up with high temperatures, slag tap, 25 and 60 cycle operation and new auxiliary drives

Crawford Station was put in service in 1924 and the last unit was installed in 1928. Located on the south branch of the Chicago River at Pulaski Road, it consists of six cross-compound turbine units and 32 boilers fired with forced-draft chain grate stokers. Steam pressure is 625 lb. and temperature 725 deg. F. Steam for units 1, 2 and 3 is reheated in special boilers to 700 deg. F. and that for units 5 and 6 is reheated with live steam

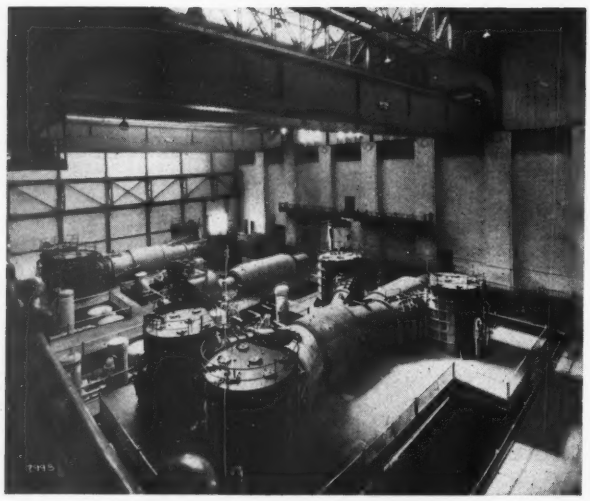


Fig. 4. The 200,000 Kw. Unit at State Line Station of the Chicago District Generating Co.

to 560 deg. F. Unit 4 has no reheat. The turbine units range in size from 50,000 to 100,000 kw. Boilers are fitted with water-cooled furnaces, some partially and some completely cooled, and with economizers and air preheaters. Station performance is about 14,600 B.t.u. per net kilowatt-hour.

Lines from the generating stations supply substations at various parts of the city, where the voltage is reduced for local distribution. For the d.c. district and railway service there is both 25 and 60 cycle supply, the older substations being equipped with rotary converters and the newer installations with mercury-arc rectifiers. In those parts of the system supplied with alternating current the transformation is more simply accomplished with transformer substations. An a.c. network has been started and is being expanded along the border of the present d.c. territory, and in this manner increases in load in the central section of the city are being taken care of without increasing the amount of 25 cycle generation and d.c. supply.

In the southeast section of the city, midway between Fisk Street and Calumet generating stations, a distributing center has been built. This is supplied from the 66-kv. transmission system and acts as the center for 12-kv. distribution to the surrounding substations, as well as for local distribution. A similar distributing center on the northwest side of the city, between Crawford and Northwest stations, will go into service this fall. The station at 25th and Quarry Streets, across the river from the Fisk Street station, has been discontinued as a generating center and now is used only for distribution to loads in this area.

Distribution from the substations in the a.c. district is at 4000-2300 volts, which is in turn stepped down for domestic and commercial customers. Large power customers, however, may be supplied either from the stations directly or from the substations with 12-kv energy supplying transformer vaults which they themselves own. There are 72 attended substations, 63 unattended substations and 233 customers' vaults.

Features of the Chicago electrical system which should hold special interest for convention delegates are the remote control substations; the new Humboldt Park Distributing Station, placed in service last year; the new alternating-current network system which supplies a portion of the Loop and near north side, and the million-volt testing laboratory.

Inasmuch as the Chicago District has an integrated supply system of some 4000 sq. in., with a peak of well over a million and a quarter kilowatts and an annual consumption approaching six million kilowatt hours, there are many other stations besides those mentioned, the eight largest and most important being shown by Fig. 1. They stretch from Michigan City on the east to Waukegan on the north and Powerton on the south and west.

State Line station of the Chicago District Gen. Co. operates at a steam pressure of 660 lb. and 730 deg. F. temperature. There are in operation at present six boilers, fired with pulverized coal and natural gas, about one-half each, and a 200,000 kw. cross-compound, three-unit, turbine-generator set. Additional boilers are being installed, which will operate at 1250 lb. steam pressure and 825 deg. F. temperature, connected to a 150,000 kw. single-shaft turbine-generator.

Waukegan Station of the Public Service Co. of Northern Illinois has five turbine-generator units, varying in size from 25,000 kw. to 115,000 kw. The first two units operate at 350 lb. steam pressure and 640 deg. F. temperature, while the newer, larger units operate at 625 lb. steam pressure and 750 deg. F. temperature. Boilers in the older section of the station are fired with forced-draft chain grates and in the newer section with pulverized coal.

Powerton Station of the Super-Power Co. of Illinois is equipped with nine boilers, fired with pulverized coal and operating at a steam pressure of 650 lb. and 725 deg. F. temperature. There are three turbine-generator units, two of 52,500 kw. capacity and one of 105,000 kw. The performance of these stations varies from less than 12,800 B.t.u. per kilowatt-hour for Powerton station to approximately 13,300 B.t.u. per kilowatt-hour for Michigan City.

Skeleton convention schedule. Inspection trips will be arranged to meet the desires and convenience of delegates. All meetings will be at the Palmer House.

TUESDAY, JUNE 1
- Registration, open at 10:30 a. m., Fourth Floor
- First Business Session, 2:30 p. m. in the Grand Ballroom
- President's Reception, 9:30 p. m. in the Red Lacquer Room (followed by dancing)

WEDNESDAY, JUNE 2
- Registration, open at 8:45 a. m.
- Second Business Session, 2:30 p. m. in the Grand Ballroom
- Buses leave the Palmer House at 12:45 p. m. to take the ladies in attendance at the convention to the luncheon and bridge at the Edgewater Beach Hotel. Buses will return to the Palmer House around 5:30 p. m.
- Third Business Session, 2:30 p. m. in the Grand Ballroom
- Dancing, 9:00 p. m. in the Grand Ballroom

THURSDAY, JUNE 3
- Registration, open at 8:45 a. m.
- Fourth Business Session, 9:30 a. m. in the Grand Ballroom
- No business session scheduled
- A Fashion Show and Tea for the ladies, at 3:30 p. m. in the Walnut Room, Seventh Floor, Marshall Field & Co.
- Banquet, 7:30 p. m. in the Grand Ballroom
- Dancing, 10:30 p. m. in the Red Lacquer Room

FRIDAY, JUNE 4
- Registration, open at 9 a. m.
- Fifth Business Session, 9:30 a. m. in the Grand Ballroom
- Adjournment, 1 p. m.

Old Stoker Performs New Tricks

By changing the ash discharge feature of old underfeed stoker from double-dump to continuous discharge, Madison Gas & Electric Co. not only increased efficiency of boiler but also capacity and is now able to use cheaper grades of coal

By

J. E. NEWTON
Supt. of Production, Madison Gas and Electric Co.

W. T. STEPHENS
Central Station Division, Westinghouse Electric & Mfg. Co.

AT THE MADISON Gas & Electric Company's Blount Street Station, Madison, Wisconsin, the problems of increased capacity and efficiency, and reduced maintenance costs have been attacked in the boiler room. The old double-dump, multiple-retort type underfeed stokers are being rebuilt into the new type continuous-ash-discharge, link-grate stoker. Favorable results have been obtained by the increased sustained capacity and efficiency of the present revamped boilers and due to the fact that cheaper grades of coal can be burned with reduced maintenance.

The Blount Street Station has four boilers; two Kidwell boilers of 1288 hp. each and two Stirling boilers of 1057 hp. each. These boilers were equipped with Westinghouse multiple-retort, 21 tuyere, underfeed stokers with steam-operated hollow-frame double dump grates. The stokers under the Stirling boilers have ten retorts and under the Kidwell boilers eleven retorts. There are no economizers or air-preheaters. The boilers are of the bent tube construction with three pass baffling. The height of the setting of the Kidwell boilers is 12 ft. The Foster Wheeler superheater is located at the top of the first and second passes. The two Kidwell boilers are tied together into a common breeching and are provided with only natural draft by a concrete stack 269.5 ft. above the boiler room floor and a 12-ft. inside diameter at the top.

Fig. 1. Old double-dump plates and refractory bridge-wall before removing to install link-grate surface and water wall

Stoker Rebuilt

Several plans were considered for revamping the old type double-dump stokers, but a continuous-ash-discharge, link-grate stoker seemed to offer the best solution. As a result it was decided to revamp the old double-dump, 11-retort stoker used in No. 2 Kidwell boiler in order to experiment with it and make extensive tests with different types of coal with a view to continuing the revamping program to the other boilers. The baffles in the boiler were changed during the summer in order to provide for larger opening for the gases in the different passes and thereby cut down on the draft loss through the boiler. Incidentally, additional cross flow of the gases with the tubes was provided in the first and second passes. The change in the

Fig. 2. Link-grate surface installed in place of old double-dump plates at the end of tuyere rows

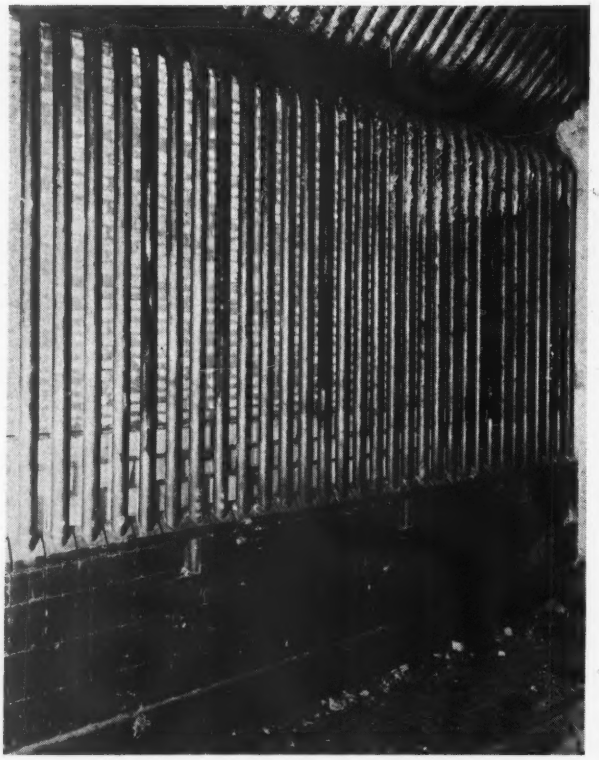


Fig. 3. Rear water wall and link grate surface

baffles was thought advisable in view of the fact that the boiler rating was to be considerably increased.

A few months later the contracts were approved for the new continuous-ash-discharge, link-grate stoker and a Foster Wheeler rear-water-cooled bridge-wall. This equipment was installed so that the boiler was ready for service again the fall of 1933. The link-grate added 39 ft. of projected burning surface to the old type of stoker. The old 11-retort, double-dump unit had 196 sq. ft. of projected area and the new unit has 235 sq. ft. of projected area or an increase of 20 per cent. The water wall unit added 237 sq. ft. of exposed area to the 12,880 sq. ft. of heating surface of the Kidwell boiler. The boiler rating with respect to the capacity of the stoker was increased from 260 per cent of normal rating for periods of 2 hr. to 325 per cent for periods of 4 hr. It is interesting to note that the increase in capacity was obtained without increasing the physical dimensions of the boiler walls except the rear ash pit wall which was moved back about 3 ft.

Improved Efficiency

Based on test conditions, the combined boiler and furnace efficiency was improved from 74 per cent at 150 per cent of normal rating to 78 per cent. The test efficiency, however, with the new type of stoker is more nearly approached in regular daily operation when varying from banked fire conditions to heavy loads. The firemen find it much easier to maintain a uniform fuel bed throughout the day on varying loads than when operating a double-dump stoker which must be burned down and dumped four or five times a day. One of the largest losses in the old double-dump stoker operation has been reduced, namely, the combustible in the ash. The new continuous-ash-discharge type very easily discharges the ash and clinker without admitting cold air to the furnace, and as a result there is no interference with the uniformity of the combustion cycle. The CO_2 can therefore be maintained at a continuous high percentage throughout the regular operating day. On a recent test, CO_2 determinations were made over a continuous period of 4 hr. with the boiler operating at an average load of 190 per cent. The following results were obtained: Average CO_2, 15.3 per cent; average O_2, 3.4 per cent; average CO, 0.18 per cent.

The readings taken on the average of every 10 min. were obtained with an Orsat apparatus and the gas analyzed was the average of four sample pipes distributed over the last pass. The refuse-discharge-plate can be adjusted for variable sized openings under the overhanging bridge wall to maintain a seal. This adjustment is conveniently located so that it can be changed for different types of coal with various ash content and for varying loads.

The following tabulation indicates two tests made at 150 per cent of normal rating, using Southern Illinois 2-in. screenings:

	Test No. 1	Test No. 2
CO_2 (boiler outlet)	14.2 per cent	14.0 per cent
Flue gas temperature	542 deg. F.	544 deg. F.
Efficiency	78.2 per cent	77.0 per cent
Coal B.t.u. as fired	12,164	12,310
Combustible in ash	18.1 per cent	12.8 per cent

Since these tests were conducted it has been found that better operating results can be obtained by using ¾ in. screenings with at least 35 per cent of the coal small enough to pass through a ¼ in. square mesh screen.

Cheaper Grades of Coal Used

Previously, when the stokers were all of the old double-dump type about 50 per cent of the coal burned was a high grade Eastern coal and the balance a Southern Illinois coal, together with a small amount of Indiana coal. The average B.t.u. required per kw-hr. of net generation for the year amounted to 29,443. In the year 1935, when about 60 per cent of the coal was burned on the new type stoker and 40 per cent on the old double-dump stokers, the average B.t.u. required

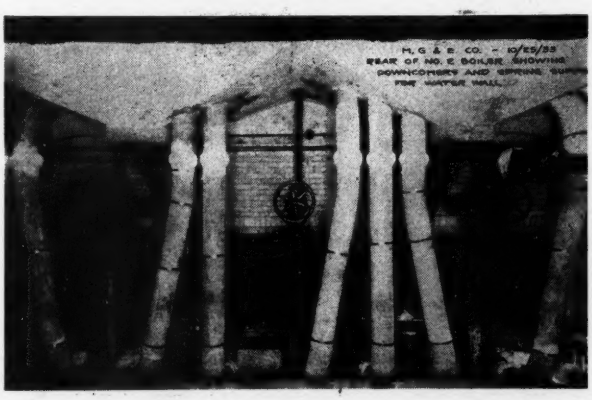


Fig. 4. Downcomers from mud drum and spring supports for rear water wall

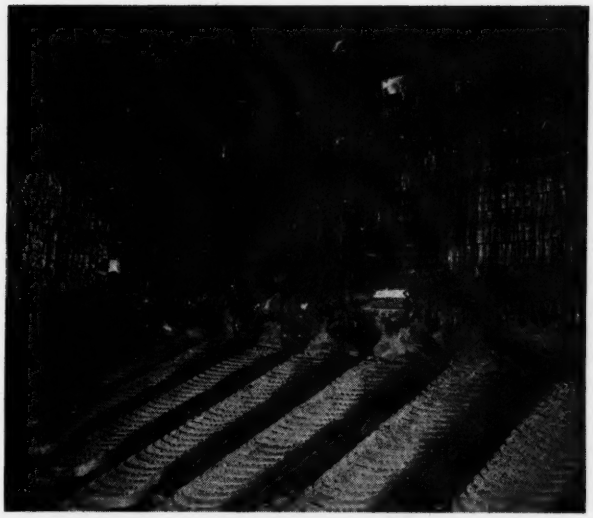


Fig. 5. Indicating washing effect of front wall due to carrying heavy loads on the boiler with a low fusion ash coal. This wall has been replaced with a front water wall. This view also indicates the plates that were installed to form the deep retorts

per kw-hr. of net generation for the year amounted to 26,550; an overall improvement of about 9.8 per cent. These figures are submitted only for comparative purposes to show improvement. It must be understood in studying these B.t.u. results that the base load at this plant is carried on water power. The boilers operate on varying loads and are banked on an average of 5 hr. each night. The coal burned during the year 1935 consisted of 11 different types from Indiana and Illinois. During the first nine months of 1936 third-vein coal from Northern Illinois has been burned and the average B.t.u. required per kw-hr. of net generation for the period has amounted to 25,562. This later figure not only indicates improved efficiency but it also shows that a much cheaper grade of coal can be burned without lowering the efficiency.

Coals with a low fusion ash have been burned satisfactorily. Whereas with the old type of stoker without agitation a low fusion ash coal would form large clinkers on heavy loads of such dimensions that they had to be broken up to remove them through the 2 ft. by 2 ft. ash pit doors. In the case of the link grate mechanism the clinkers are discharged from the ash discharge plate in small flat pieces from one to 2 in. thick and not over 6 to 8 in. in length and width. The size of the clinker from the stoker with the link-grate action is so small that it is no task at all to break it in order to feed it into the 6 in. opening in the 8 in. pipe line of the steam jet ash conveyor.

The coal which has been used over the past year is known as third-vein coal and is shipped from Northern Illinois. Geologically it is No. 2 seam coal and is strip mined. The coal used is a ¾ in. washed, dehydrated and dried screenings. The proximate analysis on the as fired basis is as follows:

Volatile matter	36.87 per cent
Fixed carbon	44.21 per cent
Ash	4.36 per cent
Moisture	14.56 per cent
B.t.u. per pound	11,659
Sulphur	1.38 per cent
Fusion temperature of ash	1923 deg. F. to 2040 deg. F.

Following a year's operation the stoker was further modernized by the installation of deep retorts, and the stoker of the second Kidwell boiler was rebuilt to include the continuous-ash-discharge, link-grate action together with the deep retorts. To date the deep retorts only have been installed on the double-dump stokers of the Stirling boilers. The deep retorts make it possible to burn the low fusion ash coal on the old double-dump stokers at the lighter loads. The deep retorts effect a more uniformly burning fuel bed with a more uniform flow of air through the fuel bed.

The last year with the heavier loads it was found that the ash from the Northern Illinois coal has a strong fluxing action on the refractories of the front wall. Considerable washing of the front wall occurred and to correct the trouble a front water-cooled wall was installed in the No. 2 Kidwell boiler. This unit has just been put back in service again and for the short period that it has been operated the results seem to be very gratifying. The two-speed gear boxes and turbine drive were also installed on this unit at the same time that the front water wall was installed. This improvement makes the stoker much more flexible than the old type single-speed gear boxes and engine drive. It is possible to maintain a much more uniform fuel bed on the stoker at all times.

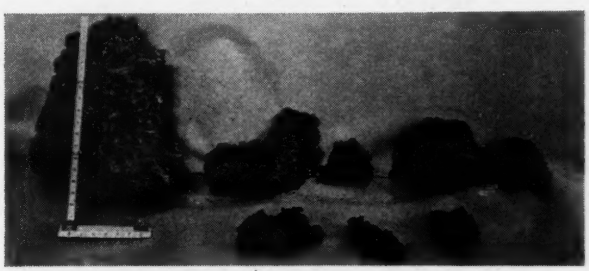


Fig. 6. At left, a large clinker from old style stoker and at right, several small clinkers from SDL-30 stoker when burning a coal with a low fusion temperature ash

Since the new type stoker was installed in No. 2 Kidwell boiler 3 yr. ago a total of 45,153 t. of various kinds of coals have been burned. During this period no new parts on the link grate surface and discharge plate have been installed until recently when it was thought advisable to replace some of the link grate castings which had been burned back at the ends. The cost of the new parts installed was very little.

The maintenance cost of stoker parts replaced on all stokers during the year 1932 before any rebuilding was done averaged $0.0245 per ton of coal burned. The cost of stoker parts replaced in No. 2 boiler on the underfeed section in 1934 with the new type of stoker amounted to $0.0146 per ton of coal burned. The average for this stoker for the 3 yr. since it was rebuilt amounts to $0.0338 for stoker castings per ton of coal burned. This maintenance is higher than the general reported average maintenance on this type of stoker. The high maintenance is due to the low-fusion temperature of the ash and the low ash content of the coal used.

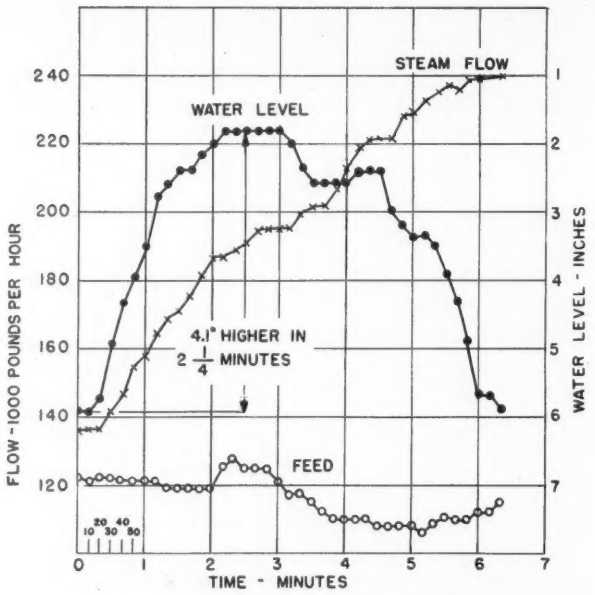


Fig. 1. In Test No. 3, plotted above, the coal feed was increased in 20 sec. The four tests covered by Table I were made without feedwater regulators and in each case the feedwater supply was kept as nearly constant as possible. In Test No. 1 the coal feed was increased in 70 sec. and the water level was 2.7 in. higher at the end of 3 min., but dropped to the original level at the end of 6 min.

HANDLING

Effect of steam bubbles and limited water capacity of modern high pressure boilers complicates variable load feedwater regulation. Water level must be varied with rating and these tests throw much light on a troublesome problem, showing, not only what takes place, but, how a feedwater regulator responsive to both water level and steam flow satisfied the exacting demands of the engineers.

BY

DR. IR. F. W. VAN BERCKEL

TO DETERMINE the characteristics of a feedwater regulator needed to hold the boiler water level within the desired limits in relation to load under sudden changes, and, to determine how closely an actual regulator conforms to the standards set, a series of tests were run at the Government Power Station in Maurits, Netherlands, under direction of the writer. The Babcock boiler used for these tests has a 54-in. upper drum, 31 ft. long. Its steaming capacity is 242,000 lb. per hr. and, including the water walls, the water content is 2436 cu. ft. up to the center of the upper drum. At maximum load the steam pressure is 485 and the feedwater pressure 570 lb. per sq. in.

Effect of Increased Load

Should the feedwater supply be entirely shut off when the boiler is steaming at full capacity with the water level at the center of the upper drum, the water level would drop 6.8 in. in 1 min. Should this condition continue, the water level would drop with increasing rapidity because the curvature of the drum would decrease the surface area of the boiler water. This would, of course, happen only under an emergency condition, as there are two boiler feed pumps in use. Should one pump become inoperative, however, it would be necessary to cut another reserve pump into service. This would mean a short period of time in which the feedwater input was below the steam output, so that the boiler water level would drop.

This emergency condition is mentioned to show how quickly interference with the feedwater flow affects the boiler water level. During normal operation, however, we do have wide fluctuations in the water level because of the small ratio of water content to the steam production.

When the boiler is steaming, the boiler water contains many steam bubbles, decreasing the specific weight of this water, exactly how much, we do not know. On an increasing load, the proportion of steam in the circulating water increases, raising the water level. The effect is commonly known as "swell." On a decreasing load, the effect is reversed and the water level lowers.

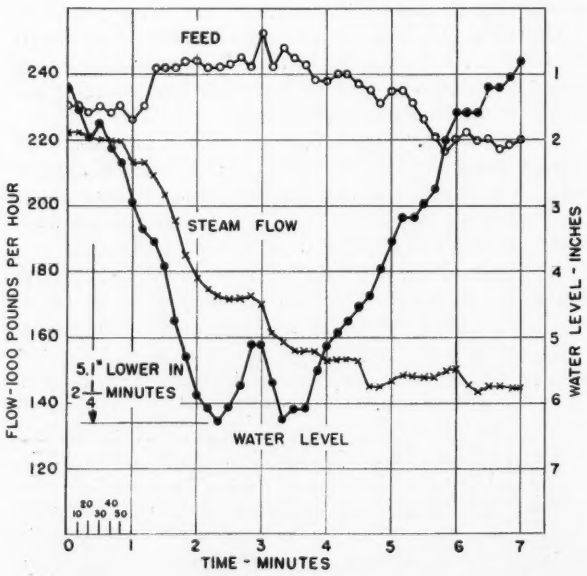


Fig. 2. In Test No. 4, plotted above, the coal feed was reduced in 30 sec. In Test No. 2 the coal feed was changed in 50 sec. and the water level dropped 2.7 in. in 3½ min. The regulator was not in service in either test

Results of two of the first series of tests are shown on Figs. 1 and 2 made under the following test conditions and without the use of the feedwater regulator.

With the boiler on constant load, a balance was obtained between evaporation, feed and water level. The

"Swell" in High Pressure Boilers

load was then increased as rapidly as possible by varying the supply of pulverized coal. Rapid decreases in load were obtained in the same way. Throughout the tests, the rate of feedwater input was held as nearly constant as possible. Steam flow, water flow and water level were recorded every 10 sec. for the four tests shown by Table I:

Table I. Fuel and steam conditions for the four tests

Fig.	Test	Coal Supply Changed In	Approximate Change in Load
	1	70 sec.	176,000 to 220,000 lb. per hr.
	2	50 sec.	176,000 to 132,000 lb. per hr.
1	3	20 sec.	132,000 to 242,000 lb. per hr.
2	4	30 sec.	220,000 to 143,000 lb. per hr.

Table II. Water level changes during the four tests

Test 1—Level raised 2.7 inches in 3 minutes.
Test 2—Level lowered 2.7 inches in 3.5 minutes.
Test 3—Level raised 4.1 inches in 2.25 minutes.
Test 4—Level lowered 5.1 inches in 2.25 minutes.

Water level changes recorded during these tests are shown on Figs. 1 to 2 and by Table II. The test could not be continued throughout the entire period of from 4 to 7 min. required for the evaporation to become constant, as the steaming rate had changed too much for the constant rate of feed.

These water level changes were not considered excessive under the test conditions, but we expect greater and more rapid changes in load from changing demands on our turbo-generators than could be simulated by varying the fuel supply. Our loads sometimes drop instantly as much as 10,000 kw., changing the steam demand some 99,000 lb. per hr.

Tests 1 and 3 were started with a low water level so the "swell" accompanying the load increases would not carry it too high. Tests 2 and 4 were started with a high water level so it would not be carried too low by the contraction on the decreasing loads. These conditions would not prevail using a feedwater regulator influenced only by changes in the boiler water level. With the load on our boiler varying between limits of The simple level control type of regulator maintains a low water level for a heavy load and a high water level for a light load, as shown by Curve 1, Fig. 3.

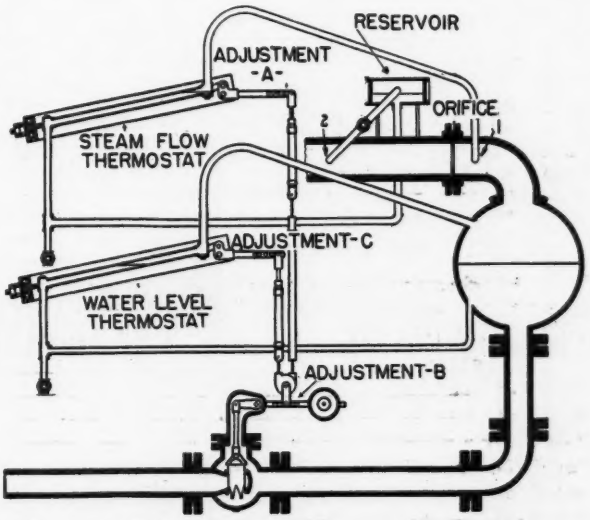


Fig. 4. Type of double control regulator installed at Maurits Station. There the orifice was eliminated and the pressure loss through a section of pipe between 1 and 2 used as a measure of the flow. The desired characteristic, for the particular conditions existing there, was obtained with the steam flow thermostat, or, Adjustment A, 2.4 times as effective on the valve lift as the water level thermostat, or, Adjustment C. The desired movement of the valve for any given change of load or level depends upon Adjustments A, B and C

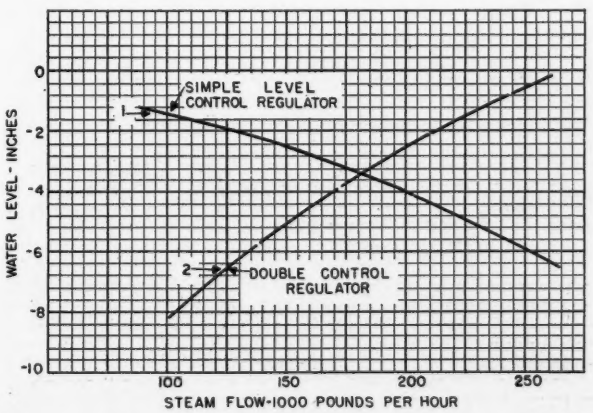


Fig. 3. Characteristics of a simple level control regulator showing the drop in level with load as contrasted to the rising characteristics given by a double control regulator, of the type shown by Fig. 4, which is responsive to both water level and steam flow

88,000 and 242,000 lb. per hr., the water level is about 7.9 in. higher on the heavy load than on the light load as shown on Curve 2, Fig. 3. At Maurits, we prefer a water level characteristic similar to that shown by Curve 2, Fig. 3.

If the load drops from a peak, we want the lowering of the water level to come from a comparatively high point to prevent it from going too low. If the load picks up suddenly from a low rating, we want the "swell" to begin from a lower point so that the level will not rise above a reasonable high limit. We get this desired water level characteristic with the Copes Double Control Regulator.

Figure 4 shows a schematic diagram for the regulator used. The steam flow thermostat tends to change the opening of the feed control valve in response to changes in the rate of steam flow, as measured by variations in the pressure drop between points 1 and 2. The water level thermostat tends to

change the valve opening in response to changes in boiler water level.

Before adopting this method of feedwater control, the relations between our steam flow, feedwater flow and water level were often as shown by Fig. 5. Our usual load fluctuations are mainly caused by electrically-driven hoists, and from these alone demands may vary as much as 6000 kw. within 10 sec. The fluctuations in our feed flow were much more severe than the necessary variations in steaming rate, because the change in water level resulting from "swell" covered a large portion of the allowable level change when going from no load to full load.

This was undesirable. The fluctuating water supply caused wide variations in the boiler water level, decreased the steam temperature and induced a tendency for loads to swing from one boiler to another. The peaks in the water flow curve decreased the pump discharge pressure when the frictional resistance in the feed line was greatest, making it necessary to work with an abnormally high average boilerfeed pump discharge pressure.

Figure 6 shows typical conditions using the Double Control regulator under exactly the same turbine conditions. The variations in water flow follow so precisely the changes in load that one curve practically coincides with the other. If anything, the feedwater curve is more regular than the steam flow curve. The water level rises as the load increases, and lowers as the load decreases. It is, as we want it, higher on heavy loads than on light loads.

At Maurits, the steam flow thermostat has a greater slope than the water level thermostat. At peak load it is nearly empty of water. There is about 39 in. of water differential between connections 1 and 2, located on one of the 13 steam pipes carrying saturated steam

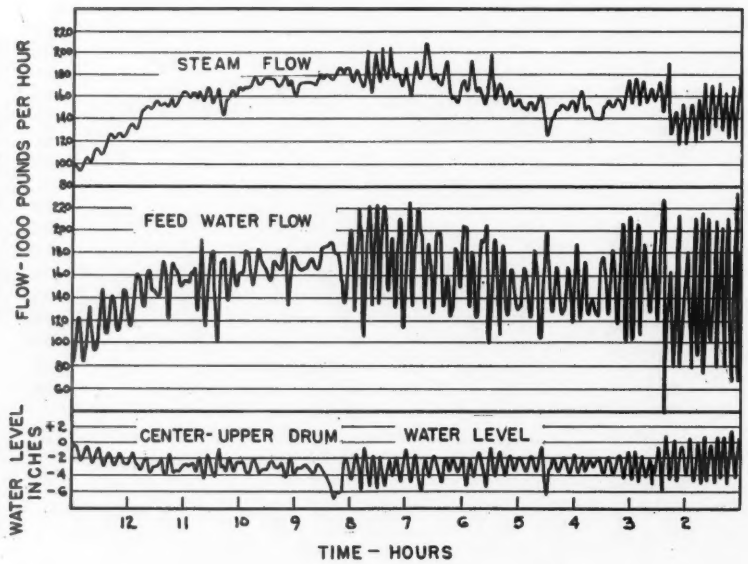
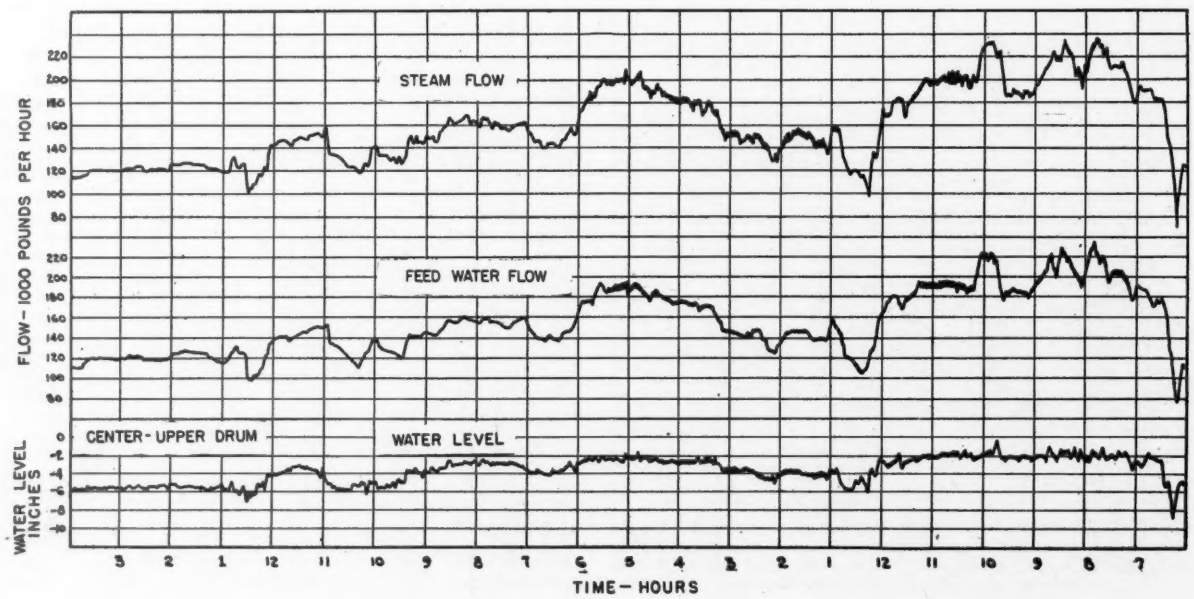


Fig. 5. (Left) Conditions existing when operating without a feedwater regulator. Contrast this with Fig. 6 for the same turbine conditions but with the regulator in service

Fig. 6. (Below) When the feedwater regulator is in service water levels are held in accordance with the desired characteristic as shown by curve 2 of Fig. 4



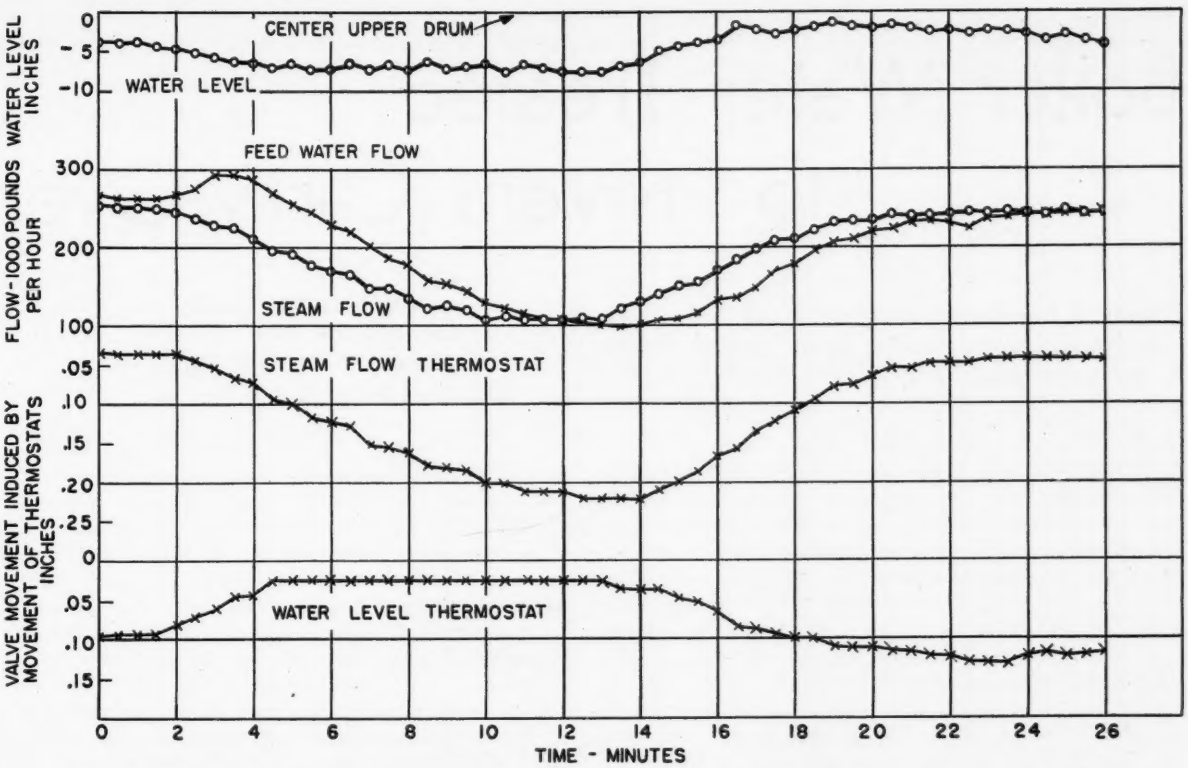


Fig. 7. More detailed tests made to show the effective action of both elements of the regulator for a load swing of almost 2.5 to 1

from the upper drum to the superheater. We eliminated the orifice by making the connections far enough apart to provide the 39-in. differential on the maximum rating.

To check the speed with which each thermostat responded to changes in load and water level, the steaming rate was varied between limits of 253,000 and 110,000 lb. per hr. Readings were taken every 30 sec. of the steam flow, the boiler water level, the feedwater flow and the movement of each thermostat lever, corrected to show the amount of resultant valve opening.

Results were as shown in Fig. 7. We found we get the best results with the steam flow thermostat adjusted to have approximately 2.4 times as much influence on the valve as the water level thermostat. This gives the desired water level characteristics, yet retains some of the inherent advantages of feedwater control from changes in boiler water level alone.

Influence of the boiler water level is apparent in the feed flow chart. At 2 min. on Fig. 7, for example, the water level lowers as the load decreases. The rate of feed is increased, permitting the boiler to store excess furnace heat and thus be prepared to give up that energy in the form of steam when the load is next increased. Thus it is not necessary to sacrifice this heat reservoir effect of simple level control to get the water level characteristic we want.

Applied Research

TEN NEW industries have been brought into being through applied research fellowships of Mellon Institute during recent years. These, and the development or invention of about 650 new processes and products, are among major accomplishments of the Institute since its founding in 1913, according to a statement by Dr. Edward R. Weidlein, its director, on the occasion of the dedication of its new building.

The Institute's work with vinyl and other resins, leading to large-scale production of five new plastics, has been especially notable. Another, dealing with the study of acetylene, resulted in a bewildering list of new organic compounds and formation of a new chemical company for their manufacture. A third, leading to discovery of an edible synthetic sausage-casing from cottonseed hulls and a way to make it on a large-scale commercial basis, succeeded in "putting cotton shirts on wieners." A fourth succeeded in wresting from ethylene a list of 75 new derivatives, again causing the birth of a new chemical company. Another paved the way for the manufacture of several important chemicals from cane-sugar.

The Institute also, in its career of 26 years, has been instrumental in developing a new type of safety-fuse, a new iodine antiseptic, a new kind of steel flooring, a novel core binder for foundry use and—coming back to the average man—a shoe leather impregnated chemically to make it highly scuff-resisting, better wearing, and capable of polishing merely by rubbing with a cloth.

Boiler Water Treated to Prevent Carry Over

Repeated burning of superheater tubes and low superheat temperature in a boiler working at 450 lb. pressure eliminated by treating the boiler water.

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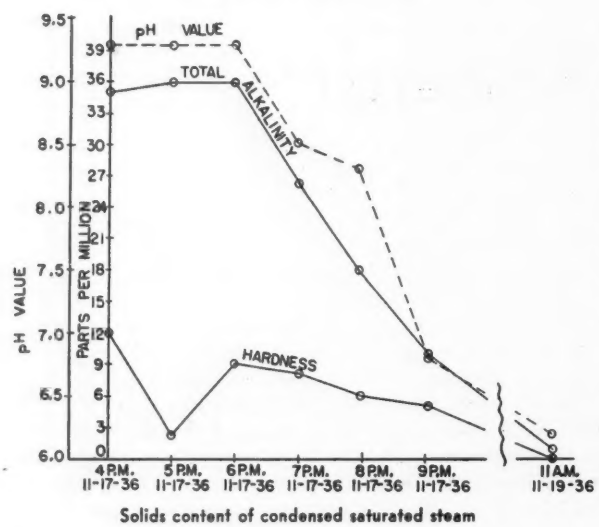
WITH the ever increasing trend toward higher standards in modern power plant operation, factors which may have been of minor importance under less exacting conditions assume the status of major problems. Entrainment of solids with the steam, the causes and methods of prevention of such entrainment are definitely factors of major importance which are better understood today than a few years previously. The physicochemical theory of foam advanced by Foulk[1] has served as a basis for a considerable amount of recent research work. The formation of liquid films is dependent upon difference in concentration between the surface layer of the liquid and the mass of the liquid. Concentration of dissolved matter in the surface of the liquid is termed positive absorption and the receding of dissolved matter from the surface is termed negative absorption. Effect of organic matter in boiler water foaming has been shown by Behrman,[2] who found removal of organic matter materially decreased tendency of water to foam. Similar results were obtained by Hancock.[3]

Severe carry over was being experienced in a large New England industrial plant resulting in the repeated burning out of superheater tubes. The temperature of the superheated steam had dropped considerably below the design temperature as a result of carry over. As is common with New England water supplies, this water is quite low in hardness and general solids content and is ideal for boiler feed purposes with the exception of the high content of organic matter. Organic concentrations in the raw supply generally reach a peak during the autumn and the greatest difficulties with carry over result during this season.

Solids carried with the steam into the superheater may be expected to deposit and, over a period of time, gradually build up scale which could cause superheater tube failure through its heat insulating qualities. It was evident, however, that plant difficulties from superheater tube failures were not primarily due to scale formation. Several superheater tubes failed after only one week of installation and upon examination showed clean internal surfaces with evidence of failure from overheating. Under these circumstances the theory was evolved that the unusually high organic concentrations of the boiler water were giving rise to an actual carry over of foam from the boiler. This foam entering the superheater tubes was short-circuiting steam passage and causing actual steam starvation of certain tubes. Resultant overheating of these tubes caused their failure with no appreciable amount of scale present.

[1]Foulk, Ind. and Eng. Chem., 21, 160 (1929)
[2]Behrman, Ibid. 21, 817 (1929)
[3]Hancock, J. Soc. Chem. Ind., 49, 369 (1930)



Solids content of condensed saturated steam

Boiler Data

The boiler was rated at 745 hp. and operated at 450 lb. pressure. Steam production varied from 90,000 lb. per hr. to 120,000 lb. per hr. with an average boiler rating of 500 per cent. The boiler was a three drum, bent tube type equipped with water walls, air preheater, economizer and superheater. Feedwater conditioning was effected through the use of phosphate and sodium hydroxide under competent supervision. Soluble phosphate was maintained in the boiler water in the required amount with hydrate alkalinity within proper limits. Boiler water was tested six times daily and tests reported to supervisory laboratory regularly.

Although the boiler had been refilled with fresh water after having been off line for replacement of superheater tubes, a complete survey of conditions by the authors made only two days later showed the condensed steam obtained between the boiler drum and superheater inlet to represent a heavy carry over condition. Samples showed high turbidity and solids content. Analyses of condensed steam obtained at 10:30

Table I. Condensed Saturated Steam, November 17, '36

Time			10:30 a.m.	1:30 p.m.	4:00 p.m.	5:00 p.m.	6:00 p.m.	7:00 p.m.	7:55 p.m.	9:10 p.m.
Hardness	as ($CaCO_3$)	Parts Per Million	12	10	12	2	9	8	6	5
Sulfates	as (SO_4)		10	8						
Chlorides	as (Cl)		3	2	2	6	2	0	4	3
Bicarbonates	as ($CaCO_3$)		18	14	11	16	16	14	14	10
Carbonates	as ($CaCO_3$)		30	12	24	20	20	12	4	0
Hydrates	as ($CaCO_3$)		0	0	0	0	0	0	0	0
pH Value			9.3	9.3	9.3	9.3	9.3	8.5	8.3	6.7

a. m. and 1:30 p. m. are shown in Table I. This continued severe carry over was obtained in spite of the fact that while excess phosphate was maintained as usual, no caustic had been added to the boiler water and the boiler had been blown down every 2 hr. during the two-day period following refilling the boiler with fresh water.

From a careful consideration of the analytical data and plant characteristics, it was evident that the effect of organic concentrations and present system of treatment in increasing foaming tendencies of the boiler water must be eliminated. This was necessary to stop the carry over and prevent the frequent plant shutdowns resulting from the failure of superheater tubes. Various organic reagents employed to date at the plant for feedwater conditioning had failed entirely in this respect as was to be expected since their properties were not adapted to such action. This difficulty with carry over of solids in the steam was not due to high concentrations of suspended solids in the boiler water nor by the maintenance of high boiler alkalinities. Dissolved solids concentration was also a factor that influenced this carry over very little. The normal cause for a carry over condition can usually be found in any one of these factors or a combination of them. The direct cause of these conditions, however, was the high organic concentration of the boiler water. Tests upon the relative organic concentration of the feed and boiler waters indicated the concentration of organic matter in the boiler water was in direct ratio with the concentration of other salts and that no material precipitation of this organic matter was being effected in the boiler under the action of heat and pressure. This was further shown by the samples of boiler water which showed low suspended solids concentration and required coagulation of the colloidally dispersed organic matter in order to clarify the water for colorimetric analysis.

Statement of Boiler Water Problem

The problem in the elimination of the carry over condition therefore hinged upon a coagulation of the organic matter which was present in the boiler as well as the feedwater in the colloidal state. Various strong electrolytes such as hydrochloric, sulfuric and nitric acid employed experimentally in the laboratory resulted in coagulation of organic matter from boiler water samples and the precipitation of this organic matter in a floc that could easily be filtered. Potassium nitrate and similar salts tested also exhibited this "salting-out" effect, although to a lesser degree. Quantities of these inorganic agents necessary to effect coagulation were so large as to preclude any possibility of their use in the treatment of the boiler water. A formulation of a reactive organic colloid was accordingly employed for this purpose on the basis of mutual coagulation of oppositely charged colloidal particles.[4,7]

Table I shows the analysis of the condensed saturated steam obtained at different periods of the day on which treatment was started. The high solids content of the first few samples will be noted. At 4:00 p.m. the feed of a reactive organic colloid was started and this material was fed continuously to the boiler. An analysis of the condensed steam obtained at 4:00 p. m. showed the same characteristics observed on earlier samples. No improvement was noted on samples obtained at 5:00 p. m. and 6:00 p. m. The sample at 7:00 p. m. showed some reduction in solids together with a drop in pH value from 9.3 to 8.5. This sample, however, showed the characteristic marked turbidity of previous samples. A further slight decrease in the solids content was observed on the steam sample collected at 7:55 p. m. The pH value showed a further slight decrease to 8.3.

The sample of condensed steam obtained at 9:10 p. m. gave visual evidence of material improvement. This sample was of excellent clarity and showed no trace of colloidal organic matter formerly carried over from the boiler. An analysis of this sample revealed a very marked decrease in solids content, together with the entire elimination of carbonate alkalinity. The pH value had decreased to 6.7. The gradual improvement in the quality of the condensed steam can be noted from the chart.

Thus, in the course of 5 hr. the heavy carry over of solids with the steam had been eliminated and a steam of relatively high purity produced through the application of the proper treatment. During this time no change had been made in the operating procedure or feedwater conditions with the exception of the introduction of a reactive organic colloid in the boiler feedwater.

An interesting fact in connection with the gradual decrease in the solids content of the condensate was that an increase in the temperature of the superheated steam was noted from the recorders even before any improvement was observed in the analysis of the con-

[4] Linder and Picton, J. Chem. Soc., 71, 586 (1897)

densed steam. Naturally, as the moisture content of the steam delivered to the superheaters decreased, the heat which previously had been applied to the evaporation of the drops of boiler water carried into the superheaters, was now free to increase the temperature of the steam. The superheated steam temperature showed a gradual increase during the time that chemical analyses of the steam showed a gradual reduction in solids.

Boiler Water Concentrations

The next step was to so raise boiler water concentrations from their present low level to a point where they would represent entirely average conditions. At the same time, the condensed steam should be continuously analyzed so as to note any possible change in steam purity due to increased boiler water concentrations. Accordingly, sufficient sodium hydroxide and sodium sulfate were added to the boiler water to quickly restore concentrations to the values maintained at the time when water conditions were normal and organic concentrations of the feedwater not excessive. Since boiler water concentrations were quite low, this procedure necessitated a heavy charge of these materials. Such a slug of treatment would result in conditions favorable to the production of carry over and would consequently afford a good test of the efficacy of the treatment. Reactive colloid was fed continuously during this period.

Analyses of the boiler water made on the following day, November 18, 1936, showed increasing concentrations with the boiler sample obtained at 7:30 a. m. on November 19, illustrating concentrations as high as would be maintained under proper operating conditions. On November 18, condensate samples were obtained from 9:00 a. m. to 4:30 p. m. and analyzed at 10 and 15 min. intervals to secure a continuous analysis of the condensed steam. Thirty condensate samples were analyzed this day showing a general average of 4 parts per million bicarbonate alkalinity and a pH value of 6.7. Samples continued free of turbidity.

A sample of condensed steam obtained at 11:00 a.m. the following day, November 19, and submitted to a complete laboratory analysis showed hardness, sulfates and chlorides as zero. Bicarbonates were present as but 2 parts per million, with free carbon dioxide as 2.5 parts per million and a pH value of 6.2. This steam sample was of exceptional purity and as pure as the distilled water in use at the plant. It was evident at this time that difficulties with carry over had been eliminated and that a steam of high quality was being produced from the boiler.

Colloidal Treatment Employed

This elimination of entrained solids was accomplished through the use of a reactive organic colloid formulated specifically for these conditions. The colloid employed was of the laminaric acid series and consisted of a mixture of laminaria stenophyllia and laminaria digitata. It was hydrophilic (water loving) in nature and had been peptized to have a particle size in a colloidal range from 1 to 100 millimicrons. The colloid was fed to the boiler feedwater in the form of the sodium sol with a multiplicity of negative charges carried on the micell. It is postulated that mutual coagulation with positively charged organic matter already present resulted in a precipitation,[5] lowering the organic matter concentration in the liquid film and reducing its effect in increasing the tendency of solids to carry over with the steam. The reaction taking place between the negatively charged organic colloid used for feedwater conditioning and the organic matter present in the boiler water does not proceed in stoichiometric proportions, but is entirely a colloidal reaction dependent upon the neutralization of the electrolytic charges carried by the colloidal particles. Pectization (the precipitation of a sol) results in the formation of a precipitated gel exposing a vast surface area for the absorption of both suspended and dissolved solids.[6] The gelatinous precipitate formed pos-

Table II. Condensed Saturated Steam After Study

Date			11-26-36	12-2-36	12-9-36	12-15-36	12-30-36	1-14-37
Analysis No.			L 254	L 561	L 806	L 1187	A 419	A 1084
Observation			Sl.Turbid	Clear	Clear	Sl.Turbid	Clear	Clear
Suspended Matter		Milligrams per liter	Trace	None	None	Trace	None	None
Organic Matter			Trace	None	None	Trace	None	None
Total Hardness as ($CaCO_3$)			0	4	0	0	0	0
Reaction			Sl.Acid	Sl.Acid	Sl.Acid	Sl.Acid	Sl.Acid	Sl.Acid
Sulfates	as (SO_4)		0	0	0	0	0	0
Chlorides	as (Cl)		0	0	0	0	0	0
Iron	as (Fe)		None	None	None	None	None	None
Free Carbon Dioxide		Parts per million	8	8	3.3	4	2.7	9.6
Bicarbonates	as ($CaCO_3$)		8	8	8	4	8	6
Carbonates	as ($CaCO_3$)		0	0	0	0	0	0
Hydrates	as ($CaCO_3$)		0	0	0	0	0	0
pH Value			6.3	6.3	6.7	6.1	6.3	6.1

[5] Thomas, A. W. "Colloid Chemistry", McGraw Hill Book Co. (1934)

[6] Alexander, J. "Colloid Chemistry", Vol. I, Chemical Catalog Co. (1926)

sesses no crystalline structure and is analogous to the gels formed in similar reactions with calcium, magnesium and other polyvalent positive ions.[7] Effect of suspended phosphate precipitates on film stabilization was reduced by the absorbing action of the gel floc. Niehaus[8] states the maximum stabilizing power is exhibited by particles between colloidal and gross dispersion and recommends maintenance of soluble phosphate below 15 to 20 parts per million. The removal of finely divided crystalline precipitates from the liquid film prevented their stabilization of the foam produced and naturally resulted in the production of a purer steam. Due to the vast number of negative charges carried on the colloid micell in comparison with the single or double charges carried on inorganic ions experimented with, a high reactive ratio was obtained and it is necessary to use but a relatively small quantity of material to obtain the desired results.

The quality of the steam obtained during this study has been maintained since that time. Table II shows the analysis of the condensed saturated steam samples obtained over several weeks time and submitted to a laboratory analysis. Daily tests are also made on the steam at the plant to check upon its purity. During this time, blow down has been maintained between 1.0 and 1.5 per cent.

Rise in Steam Temperature

It has previously been mentioned that as a reduction in carry over was effected, an increase was noted in the temperature of the superheated steam. Average superheated steam temperature previous to our study was 590 deg. F. An increase of 50 deg. F. was observed during the first three days following application of colloidal treatment. A further increase of 20 deg. F. was effected within a week. Present average superheated steam temperature is 660 deg. F., representing an increase of 70 deg. F. Although the aggravated difficulties with superheater tubes have been due to an unusually high organic concentration in the feedwater, a certain amount of carry over had been taking place even when these unusual conditions were not present. The reduction in superheated steam temperature due to this factor has been eliminated. Increased steam temperature resulted in an improvement in operating efficiency and in comparison with the frequent plant shut-downs formerly necessitated, it has not been necessary to replace a single superheater tube following this change in feedwater conditioning.

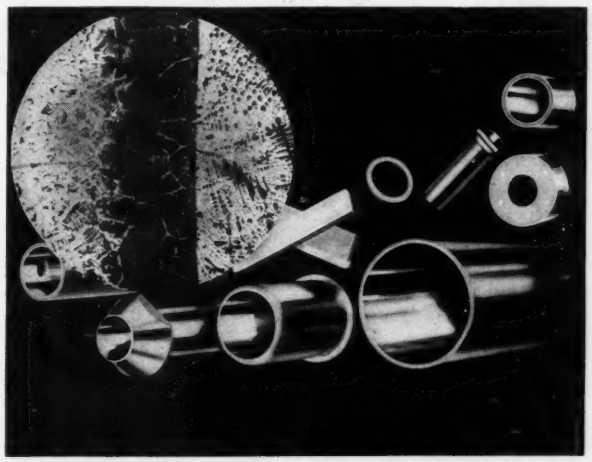
While this problem consisted in the elimination of carry over due primarily to the high organic concentrations of the boiler water under a straight crystalline method of treatment, the method of attack employed lends itself readily to the solution of other problems with carry over which may not necessarily be due to the particular factors covered in this instance. Application of sound principles and the knowledge gained from previous problems together with the use of the various treatments available provide engineers with the necessary tools with which to obtain similar results wherever carry over is a problem.

[7]Betz, L. D. and Sheen, R. T., Combustion, May (1936)
[8]Niehaus, Vom Wasser IV, p. 140 (1930)

Diesel Engine Liners

New alloy expected to find wide application in the Diesel industry

WHERE HIGH HARDNESS and unusual resistance to abrasion is desirable but high impact values and ductility are not important, a new alloy may be used to advantage. Although this alloy has been in use in oil well equipment for some time under the name of I. R. Metal, it is now being made available to a broader field by the Wilcox-Rich Division of the Eaton Mfg. Co. of Detroit, Mich., under license from Industrial Research Laboratories, Ltd. It has a tensile strength of 43,000 and a compression strength of 240,000 lb. per sq. in., a coefficient of thermal expansion of 7.2×10^{-6} per in. per deg. F., a thermal conductivity 7½ B.t.u. per hr. per sq. ft. per deg. F. and a hardness equivalent to 750 Brinell or 68 to 70 Rockwell C scale.



Liners, bushings and bars with a centrifugal cast hard inner alloy surface. The insert shows the intimate bond between the alloy and steel. Magnification is about 37½ times

One of the principal applications is for cylinder liners for engines, compressors, pumps, etc. For this use the Xaloy is applied as a lining to the inside surface of steel tubing. This construction gives strength, rigidity and ease of machining of steel on the outside, combined with a bore surface of extreme hardness and resistance to abrasion.

This lining is cast centrifugally into the steel tubing. Lining thickness is controlled within narrow limits so that a minimum amount of finishing is required. This finishing may be done by grinding or honing to give a mirror-line surface conducive to an extremely low coefficient of friction and a minimum rate of wear.

In ascertaining the usefulness of Xaloy in the general industrial field, the manufacturer has met with outstanding success in a variety of applications. For instance, it was found that the life of tool bushings is lengthened 500 to 600 percent. Exceptional results were also obtained by the use of Xaloy as an internal liner for honing control-bushings which have a continuous wiping-wear on the inside diameter aggravated by the presence of abrasive compound.

Industrial Control Standards

Standards undreamed of a few short years ago are being written by users into control specifications today. From a broad background of experience in solving unusual and difficult problems, Mr. Shugart discusses the question of how far the prospective buyer is justified in demanding performance above the current standards. This insistent demand for better performance has resulted in higher standards and improved equipment so that the control industry feels confident that it can meet any specifications and solve any problem the buyer is willing to justify.

By H. H. Shugart, Vice President
A. W. Cash Company, Decatur, Ill.

EVERY PHASE of industrial activity is characterized by a steady stream of development, a march of improvement so rapid in its progress that it seems to be an accelerated form of evolution. Every once in awhile someone demonstrates this progress in a graphic way by publishing pictures showing the evolution of the locomotive from the oldest and uncouth wood burner down to the latest and sleekest streamlined beauty of the day. This same demonstration could be made with any phase of industrial activity, particularly of apparatus used by industry. Because of its technical aspects, this might not take a form so striking to the public eye, but the story is there just the same, with the same steady approach towards perfection.

What brings this about? Are improvements in apparatus, for example, induced by the force of competition? Are they achieved because here and there individuals with restless minds try to do this thing and that thing better than it has ever been done before? Or is it possibly a combination of those factors and some others? Among the other factors, we wonder if there is not one which looms up large in its influence. We refer to the rapid rate at which the buyer, and his progressive engineers, have been elevating their standards. When a buyer writes a set of specifications which are tougher than ever before, and says, "Here's what I want; and I'm willing to pay for it"—surely that is a potent force for progress. What could more effectively stimulate the manufacturer to improve the apparatus that he wishes to sell?

Let us examine the idea. Consider, for example, apparatus for the automatic control of fluid pressures, levels, and flow, in general the automatic regulation of anything that will flow through a pipe, duct, or conduit. Further by way of emphasizing the way in which buyers and their engineers really have been elevating their standards, let us ask: When in the recent past would any engineer have thought seriously of writing into his purchase order a guarantee as exacting as the one that follows? It pertains to controllers to automatically regulate, by hydraulically operated dampers, the flow of air, by volume, through ducts:

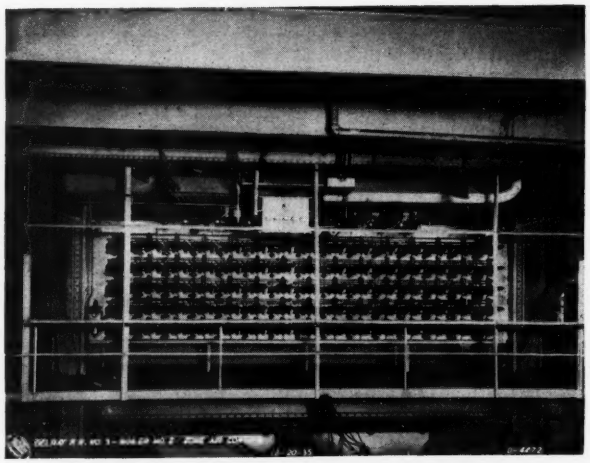


Fig. 1. This group of controllers is volumetrically regulating the flow of air responsible for uniform combustion conditions on one of the world's largest underfeed stokers. They meet the exacting guarantee of operating within 0.005 in. of water at different pressures of from 0.01 in. to 0.05 in.

"Guarantee: The controllers for each Venturi box shall maintain a constant flow of air at any differential pressure within 0.005 in. of water from 0.01 in. to 0.5 in., and, within 0.01 in. from 0.5 to 4.0 in. And the 12 controllers in each group shall coordinate within 0.005 in. of water from 0.01 to 0.5 in., and within 0.01 in. from 0.5 to 4.0 in."

Those guarantees were accepted, and met, by the automatic controllers illustrated in Fig. 1. Naturally, since these controllers were to regulate such low pressures, a higher outside pressure-operating medium had to be employed to energize the piston for moving the damper. Obviously, in order for the controller to respond to such infinitesimal pressures and work accurately within the narrow limits prescribed, friction within the controller had to be eliminated in an exceedingly thorough way, both with respect to the pressure responsive mechanism and the valving mechanism.

The point we are making is that an exceptionally high standard was set by the purchaser, a standard outside the scope of any equipment available a few years ago—and the standard was met by refined equipment. Thus, the discriminating buyer, by elevating his standards, forced into existance a newer and better tool for industrial use—a precision instrument with which to accomplish precise results.

Such a tight guarantee as the one quoted above might seem to be so much fol de rol to the uninformed man and he might ask, "By what right do those engineers write such a tough ticket?" The simple answer is that the precise performance specified was actually required for what they wished to accomplish. Since they were pioneering with an experiment which was to cost their company many thousands of dollars, they were reasonably within their rights in demanding from the apparatus manufacturer a guarantee that his equipment would click with the rest of their equation.

Some might want to throw out this job as evidence, claiming it too exceptional to support any general theory that high buying standards really pushed up the

level of the industry as a whole. "Surely pressure regulation has not gone high hat like that in many quarters," some might say. We think it has. At least it is on its way. For instance, let's look at a man who wanted a—"¾ pressure reducing valve," as he said. He had air available at 30 to 37 lbs. pressure. He wanted it reduced. "Not to 5 lb., mind you. I want a pressure of 138.5 in. (of water) on the nose," said he. "I shall measure it with a water column, and I intend to be tough about it."

His demands were met. His 138.5 inches pressure were held within a total variation of 1/64 in. of water. He was justified in setting up high standards for the apparatus manufacturer to shoot at, and it paid him well, because he was enabled to speed up a bulb blowing machine from a production of 1,000,000 to 1,300,000 electric light bulbs in 24 hr., and practically eliminate culls as well. This man did himself a service, but also he elevated the standard of the industry as a whole, because he helped put in circulation, not a mine run valve, but a high grade precision unit of control equipment.

Take another bread and butter instance of a buyer

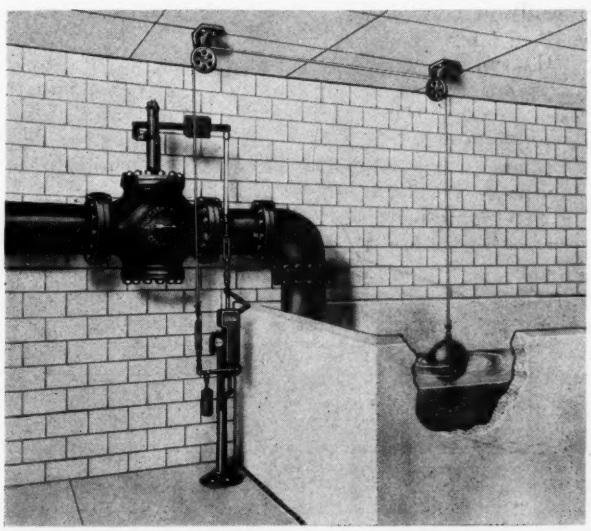


Fig. 2. "Supply pressure, erratic. Demand, variable. Liquid level must be held within a total variation of ¼ in."

who insisted on getting the best possible performance in such a simple thing as liquid level control. The specifications gave general facts and also read: "Supply pressure: erratic. Demand: variable. The liquid level must be held within a total variation of ¼ in. of water. Entire dependability is an economic factor with us." These demands were met by the apparatus shown in Fig. 2, with regulation held closer than demanded. The result to the purchaser was precise control of liquid for an important process which speeded up his process and improved his product. And again, the high standard set by him had a beneficial effect on the automatic apparatus industry.

Instances of a similar nature might be multiplied. A paper mill manager, for example, had a steam supply (partly by-products) which varies between 41 and 43 lb. He wanted to deliver 70,000 lb. per hour at exactly 38 lb. pressure, to a paper machine. When he found this could be done well, despite the low differential pressure through the reduction apparatus, he demanded that he also be enabled to depress the reduced pressure setting at will from a push button station 1500 ft. away from the automatic control equipment. His wishes were met. A fussy buyer to be sure, yet this installation, and two like it, have saved him by his own computations, more than $2,000 a year, and, he contends, have helped him to make better paper.

A natural gas pipe line station had a problem. They needed a single stage 550 to 310 lb. reduction. They preferred four valves, two 8 and two 10 in., that work in unison, because with a single large valve they experienced trouble from undue line turbulence, vibration and with freezing due to refrigeration. To complicate matters, they wanted to be able to assume instant manual control of any, or all, of the four valves at any time. The goal was twofold: uninterrupted service to their consumers, and, maintenance of the reduced pressure so constant that the meters according to which they are paid would register accurately under all load conditions. Figure 3 illustrates the answer to these demands.

Summing up, there seems to be no doubt that the buyer and his engineers have grown meticulous, asking for greater and greater precision under hard operating conditions, always demanding more elaborate and more dependable automatic control apparatus. As apparatus manufacturers, we say this is a good thing, good for the buyer and good for the apparatus manufacturing industry. For every time a standard is raised a little higher, and apparatus is brought forth to meet it, it means that from then on neither the buyer, the engineer, the competing apparatus manufacturer, or anyone who hears about it, will ever again be quite satisfied with lesser performance of inferior apparatus. The standards of all go up together.

But, you may ask, "Does not this general elevation of standards carry with it a general elevation in the level of costs?" Not always; often the new and better equipment costs less. Always it does a better job as a working, productive tool for the buyer; not to mention the matter of lower maintenance costs and greater longevity. Very frequently, the discriminating buyer with his high standards is like the old lady who used to go shopping with her market basket, and come home with the most luscious strawberries, the most solid tomatoes, the choicest cuts of meat. "And," she woud tell you, "they didn't cost a penny more. I just shopped around till I found them."

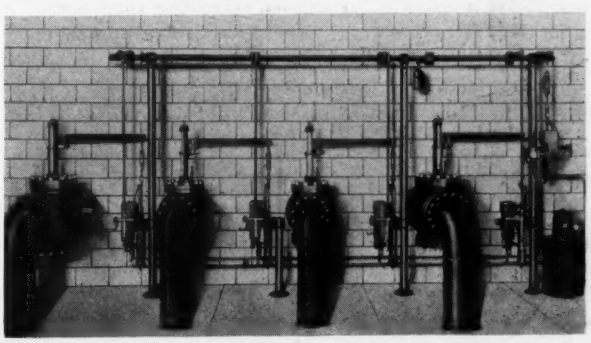


Fig. 3. Four valves in parallel automatically reduce gas in a single stage from 550 to 310 lb. pressure. Arranged for optional manual control of any or all valves

Isloating Diesel Vibration

Cork and Mechanical Dampers Effectively Solve a Troublesome Problem at Small Cost

As Told to Francis A. Westbrook by

ERNEST B. ALLEN, Consulting Engineer, Boston, Mass.

IMPROVEMENTS in diesel engines have not been confined entirely to the engines themselves. Their advantages have become appreciated, and as their use extended due to changes in design making them more economical, simple and easy to operate, but other improvements which have contributed to their increasing popularity. One of these is the silencer which has effectually overcome the serious objection of noise. The other is the development in methods of installation so as to prevent the transmission of vibrations which in the past has caused annoyance in some instances even leading to legal proceedings. Much investigation and research has been necessary to accomplish this, but engineers have now reached a point where they understand this problem and are in a position to make proper recommendations.

Diesel engines have the same unbalanced forces as gas engines, plus greater free forces due to the high compression and high temperature, the pressure per square inch being high and the pistons large. Consequently the question of vibration is more serious than with any other prime mover and unless measures are taken to absorb them adequately, serious difficulties may develop. Taking care of the vibrations at the time that the engine is installed is a fairly simple and inexpensive matter, but correcting the difficulty after installation may be troublesome and certainly more costly.

In general three ways of localizing the vibrations have been found to be effective: Use of live cork sheets properly installed; mechanical dampening devices; and, the use of cork blocks held properly, as will be explained later.

For large diesels, sheet cork is probably the least expensive as it fits in well with the special foundations

Fig. 1. Pit lined with cork sheets. The cork will be covered with waterproof paper and the concrete foundation, after pouring, will thus be isolated and machinery vibrations localized

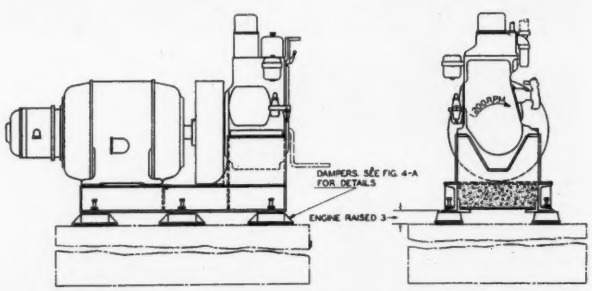


Fig. 2. Small single cylinder engine set on six mechanical dampers of the type shown by Fig. 4A

these units usually require. A pit with concrete bottom and sides is lined with the cork sheets, as shown by Fig. 1, and a concrete block large enough for the base of the engine is poured in the pit. This heavy block absorbs and distributes the vibrations of the large comparatively slow moving engines, and the cork sheets on which it rests completes the absorption and prevents the vibrations from being telephoned beyond the confines of the pit. This may be strikingly observed by placing one's foot on the engine foundation where some vibration is readily discernible, and then placing it outside the cork lined wall. If the installation has been made properly it will be impossible to feel any vibration.

In general, it may be said that the mechanical damper is preferable for high speed single cylinder engines and the most economical because the dampers may be set on the floor without extra foundation cost. They are very simple to install and can be supplied with the engine and they absorb the high frequency vibrations very effectively. A typical job of this kind is shown in Fig. 2.

Special conditions may also make the use of dampers advisable, particularly when installing engines in existing buildings. Such an installation is shown by Fig. 3.

The third method of isolation referred to is illustrated in Fig. 5. It is designed for units which are too light to properly load the cork plates and where the expense of the mechanical dampers is not warranted. That is, for the cork plates to function satisfactorily as vibration isolators they must be adequately loaded. If this is not done by the weight of the machinery which they support, some outside means for adding the compressive force must be applied. The device shown in Fig. 5 has been designed to care for such conditions and consists of cork blocks held in angle irons for the base and a T-iron engine support. In this way the

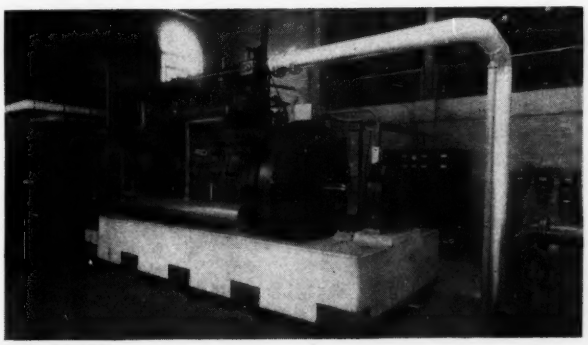


Fig. 3. Installing this new 300 hp. gas engine in this way made it unnecessary to disturb the floor or pumps installed in the basement below

weight is concentrated on small enough areas of cork to load it so that it will act at maximum efficiency and at the same time provide a proper base for the unit to be supported. It is to be noted that there are no metal to metal contacts whereby vibrations may be telephoned beyond the base. For such jobs, it is, of course, necessary to know the weight of the machinery with some accuracy in order to secure the right size of cork block.

Now let us consider a few actual cases of these different kinds of isolation jobs. The mechanical vibration dampers were installed on the six large Worthington diesels recently purchased by the Namm department store in Brooklyn, N. Y., where it was extremely important to eliminate objectional vibrations, and they proved to be entirely successful. In this there are five 6 cyl. engines of which the smallest is 150 hp. and the larger ones 300 hp. Two different sizes of dampers of the type shown by Fig. 4B were used, one having a loading range of 6500-9000 lb. and the other size 8500-11,000 lb. The number of dampers varies from eight to fourteen per foundation. These dampers support channel irons imbedded in a concrete foundation block poured over them and the engines are fastened to these blocks. The latter may be removed for inspection and adjustment of the tension of the dampers by means of bolts. In other cases where an existing engine is to be isolated for vibration the dampers may be inserted between the engine base and the foundation. This is more economical,

The 175 hp. Diesel installed at the A. D. Ellis Mills,

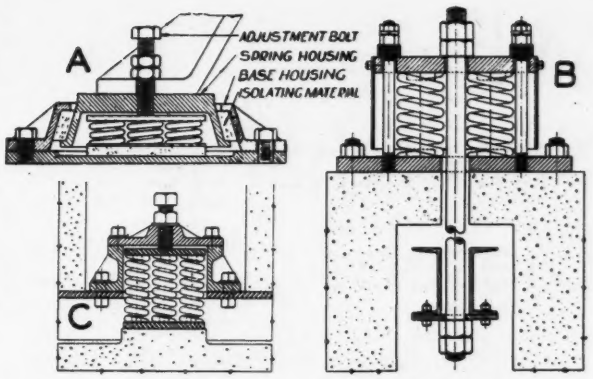


Fig. 4. Three mechanical damper designs

Inc., Monson, Mass., was isolated with the cork plates. A pit was dug out for the foundation and lined with concrete. On the bottom of this were placed cork plates 3 in. thick. The sides were covered with 1½ in. thick cork. The latter was covered with heavy waterproof paper and the concrete foundation block was poured in this. Its size is 8 ft. wide by 5 ft. deep by 16 ft. long. The reason for the waterproof paper is to keep the concrete from extending into the pores of the cork and making small fins which would tend to decrease its resiliency and hence lessen its vibration absorbing properties. The cost of the cork for this job was about $400.00, and all vibrations were satisfactorily isolated.

Dampers made of cork blocks held in place by angle irons and for use with small units are not at all expensive. For instance, for the small unit shown in Fig. 5, a 4 cyl. engine weighing only 3250 lb. and driving a 25 kw. unit, the cost was only about $65.00. The method of installation is obvious and may be seen from the picture.

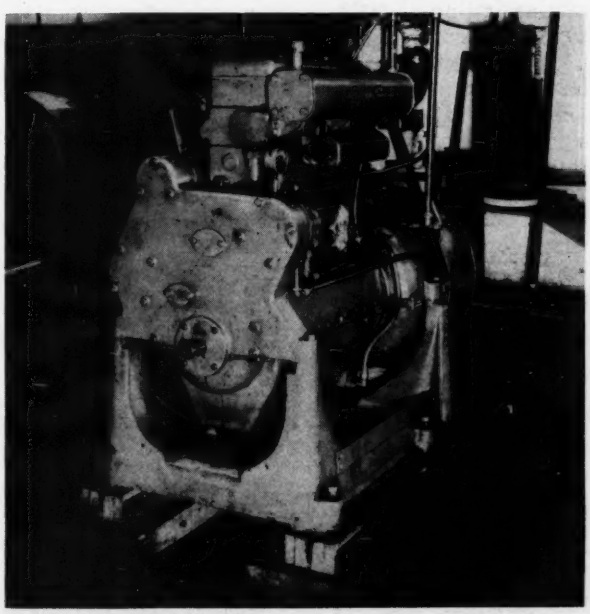


Fig. 5. To make an effective isolator, cork must be properly loaded. This type of damper may be made in any length or width and may be preloaded according to the weight to be carried

Why Supercharge Diesels?

Tests* at Langley Field Show What May Be Expected of High Speed Compression Ignition Engines in the Way of Maximum Pressures and Increased Output

By Charles S. Moore and Hampton H. Foster, Langley Memorial Aeronautical Laboratory

PERFORMANCE TESTS were made using a rectangular displacer arranged so that the combustion air was forced through equal passages at either end of the displacer into the vertical-disk combustion chamber of a single-cylinder, four-stroke-cycle compression-ignition test engine. After making tests to determine optimum displacer height, shape, and fuel-spray arrangement, engine-performance tests were made at 1500 and 2000 r.p.m. for a range of boost* pressures from zero to 20 in. of mercury and for maximum cylinder pressures up to 1150 lb. per sq. in.

Engine operation for boosted conditions was smooth, there being no combustion shock even at the highest maximum cylinder pressures. Indicated mean effective pressures of 240 lb. per sq. in. for fuel consumption of 0.39 lb. per hp. hr. have been readily reproduced during routine testing at 2000 r.p.m. at a boost pressure of 20 in. of mercury.

In this test engine combustion chamber, a rectangular displacer generates, during the last part of the compression stroke, a forced symmetrical air flow through a passage at each end of the displacer resulting in rapid rotational air movement or turbulence within the vertical-disk combustion chamber. The air movement persists during the injection of fuel from multiple orifices, proportioned according to the volume of air to be served, so that fuel and air mixing is effected both by direct injection and by forced and residual air movement.

Figure 1 shows the combustion chamber, fuel-spray arrangement and assembly of equipment used in obtaining the performance results at 2000 r.p.m. Prior to obtaining the engine performance presented in this report, work was done to develop further the combustion chamber and fuel spray to optimum conditions. A height such that the displacer entered the throat at 43 deg. b.t.c. gave the maximum brake performance and was accordingly adopted.

In order to determine the fuel-spray requirements for this combustion chamber, an extensive series of nozzles was tried; namely, 2-, 3-, 4-, 5-, 6-, and 7-orifice nozzles, as well as slit and impinging-jets nozzles. It was found that the optimum fuel spray (Fig. 1) was given by a multiple-orifice nozzle having six orifices in one plane, the areas of which were proportioned according to the volume of air each was to serve, as in the case of the quiescent combustion chamber.

As a conclusion to the work at 1500 r.p.m., using the straight-side displacer shape, the engine performance was investigated for boost pressures from 0 to 10¼ in. of mercury while the maximum cylinder pressure at full load was held constant at 880 lb. per sq. in. by retarding the injection advance angle with each increase in boost pressure. The results of these tests are presented in Fig. 2A for comparison with the later results at 2000 r.p.m.

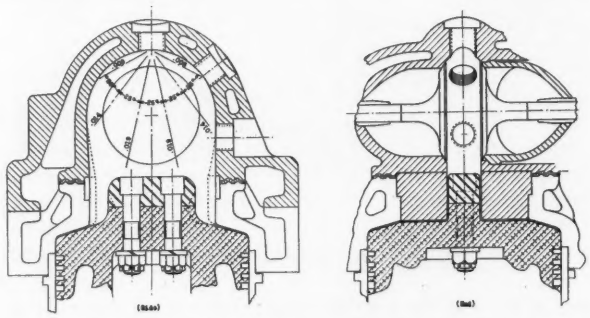


Fig. 1. Sections through the engine. Previous tests determined that maximum performance was obtained when the displacer height was such as to enter the throat at 43 deg. before top center. The fuel nozzle had 6 orifices in one plane, the diameters as indicated on the side view being such that the area of each orifice was proportional to the volume of air it serves. The length of the spray lines indicate relative spray lengths for an injection angle advance of 10 deg. b.t.c.

2000 R.P.M.—UNBOOSTED

Motoring and power tests were made at 2000 r.p.m. with the same valve timing, induction and exhaust systems that were optimum at 1500 r.p.m. Lower values of volumetric efficiency indicated the need for a change in the valve timing and inlet and exhaust piping. An aluminum-alloy piston with the displacer cast integral was used for the 1500 r.p.m. tests. During the preliminary tests at 2000 r.pm., the corners of the displacer were badly burned. The top half of the damaged displacer was machined off and a stainless steel cap, held on monel metal bolts (Fig. 1), was used. No further trouble was experienced from burning of the displacer.

In order to decrease the pumping losses the passage throat was widened from the dotted to the solid outline shown in Fig. 1, causing an increase of 63 per cent in the area of the two passages formed with the displacer in the throat. This increase in passage size decreased the compression ratio from 15.2 to 14.6. Subsequent tests showed a slight decrease in friction mean effective pressure, no appreciable change in volumetric effi-

*Reported completely in Boosted Performance of a Compression Ignition Engine with a Displacer Piston, N.A.C.A. Technical Notes No. 569. Except for the title, the term "boost pressure" is used in this summary as in the original and in accordance with aeronautical practice defined in Technical Report No. 474, as: "To supply an engine with more air or mixture than it would normally induct at sea level." In the same report supercharge is defined as "To supply an engine with more air or mixture than would be inducted normally at the prevailing atmospheric pressure. The term supercharged is generally used to refer to conditions at altitudes where the pressure in the intake manifold is partly or completely restored to that existing under normal operation at sea level."

Boost pressures in this article were measured by a manometer in a 12 cu. ft. receiver between the Roots blower and the engine manifold.

ciency, but a considerable improvement in both brake and indicated power and economy.

Tests at the full-load air-fuel ratio of 14.5 and 880 lb. per sq. in. maximum cylinder pressure showed an increase in i.m.e.p. with speed. The valve timing and inlet and exhaust piping favored the higher speed range. The 12 per cent increase in volumetric efficiency does not account for all of the 19 per cent increase in mean effective pressure, which, more likely, resulted from a combination of volumetric efficiency, air-flow speed and scavenging.

At an air-fuel ratio of 14.8 there was a nearly uniform increase in maximum cylinder pressure and power output, but a decrease in fuel consumption as the injection advance angle was increased. There was little, if any, combustion knock even at the highest cylinder pressure.

2000 R.P.M.—BOOSTED

Using a boost pressure of 7.5 in. of mercury, the trends of the curves are the same as those for unboosted operation, but the maximum cylinder pressures and mean effective pressures are higher for the boosted engine, there being little or no difference in specific fuel consumption. For equal injection advance angles the higher compression pressure of the boosted air charge resulted in an increase of about 100 lb. per sq. in. in maximum cylinder pressures. As the power to deliver the intake air at boost pressure has not been measured, the brake performance results are presented on a gross basis.

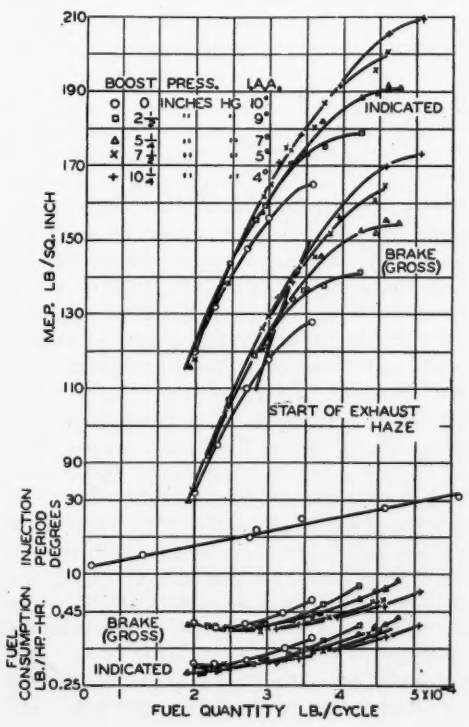
Figure 2B shows the results of variable fuel quantity tests up to 15 in. of mercury boost pressure. One point is included from a test of 20 in. of mercury boost pressure at which a gross b.m.e.p. of 200 lb. per sq. in. was obtained at a gross fuel consumption of 0.47 lb. per b.hp. hr. At a slightly higher cylinder pressure, a brake mean effective pressure of 208 lb. per sq. in. was obtained.

Note the increase in mean effective pressure and decrease in fuel consumption at 15 in. of mercury boost pressure for an increase in maximum cylinder pressure from 1010 to 1060 lb. per sq. in. Comparison of tests shows that the results at 2000 r.p.m. at somewhat higher maximum cylinder pressures were nearly as good as those at 1500 r.p.m. For both speeds the operation became exceptionally smooth with increasing boost pressure. Exhaust gases were observed in the room as they issued from a hole in the exhaust pipe located about 10 in. from the exhaust valve. The point at which haze appeared in the exhaust is indicated on the performance curves.

The ratio of maximum cylinder pressure to compression pressure decreased as the boost pressure was increased. If the ratio for the unboosted test were maintained for the boosted tests, the maximum cylinder pressures would be considerably higher and the performance values correspondingly higher. At 20 in. of mercury boost pressure the estimated maximum cylinder pressure would be 1450 lb. per sq. in. The rate of pressure rise would, however, probably be considerably lower than at no boost, owing to the decrease in ignition lag with increase in boost pressure. Thornycroft found that the period of ignition lag is very nearly inversely proportional to the absolute pressure of induction. Thus, the full value of boosting is not realized unless the ratio of maximum cylinder pressure to compression pressure is maintained constant.

It may be noted that the trend of the friction m.e.p. curve is downward as the boost pressure is increased. The slope of this curve depends upon the amount of work done upon the cylinder gases when they are forced through the flow passages as well as upon the boost pressure. In order to maintain low pumping

(Continued on page 359)



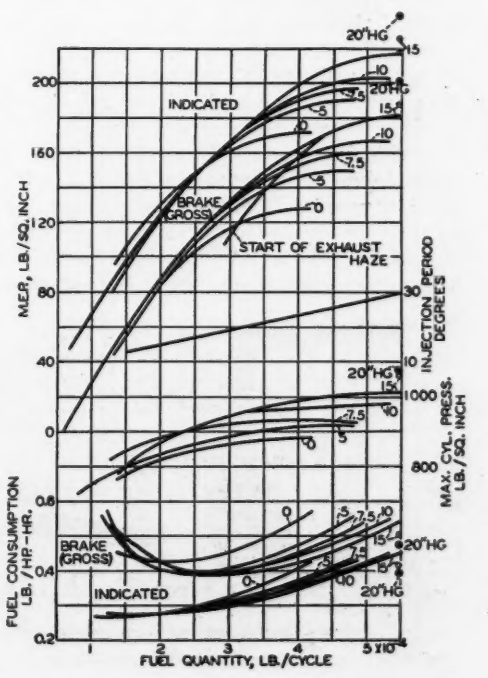


Fig. 2. Engine performance for various values of boost pressure. Left, for 1500 r.p.m. and a compression ratio of 15.2. Right, for 2000 r.p.m. and a compression ratio of 14.6

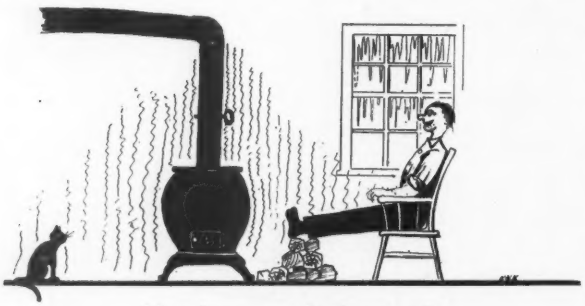
Part XVI. If you are not interested in theories you need not read this article; you can go to the movies or do anything else you like, but if you do want to know something further about the fundamental theories underlying photoelectric phenomena, you will find in this article plenty to occupy your thoughts. It deals with radiation phenomena and its relation to the photoelectric effect.

ELECTRON TUBES— Principles and Applications

By A. W. KRAMER

THE PHOTOELECTRIC EFFECT, we have seen, is the name given to the power of light, X-rays and similar radiations in causing certain substances to emit electrons, and, as such, it is the principle which has made possible the phototube. The phenomenon is important and interesting from several points of view, chief of which is that it represents one of the three or four fundamental interactions between radiation and matter. By this we mean that it concerns the way in which energy in the form of light and X-rays is handed over to matter and vice versa. It is a strange phenomenon; indeed, in the explanation of the photoelectric effect we come as close to one of the fundamental secrets of nature as we do in any study man has engaged in.

As was shown in the preceding chapter, the phototube is easily explained; it is simply a device for controlling an electric current by means of light. Now, we will concern ourselves with a more detailed consideration of the photoelectric effect itself. Those who are interested only in the simple action and application of the tube but not in the theories underlying its action may skip this installment and go to the movies or amuse themselves otherwise, but to those really interested in knowing what it is all about, this chapter should provide plenty of food for thought.



You have sat in front of a red hot stove——

The laws governing photoelectric phenomena are easier to express than to understand. Their study has raised many points of great interest regarding our views as to the real nature of radiation since they bring to light a behavior apparently irreconcilable with the simple continuous wave theory used to explain light phenomenon. Also, they maintain their validity over an enormous range of wave lengths, a fact difficult to explain. Ordinary visible light, for example, has a wave length a million times greater than that of short X-rays, yet the relation governing the speed of the ejected electrons is the same in both cases.

We will not attempt to present an exhaustive discussion of the nature of electromagnetic radiation, but in order to discuss the photoelectric effect, certain facts regarding radiation should be understood. We should know to a certain extent what is meant when we speak of electromagnetic radiation. None of us have any doubt in our minds as to what is meant when we speak of light, or heat, or even X-rays, though it might be difficult to explain these terms. When we speak of radiation, however, we may not be so sure as to what is meant—it is a more technical term; yet light, heat and X-rays are all examples of radiation.

All of you at various times have sat in front of a stove on a cold winter day and watched it turn first a dull red and then a cherry red. As it became red hot you backed away from the intense radiant heat that was thrown out and sought a cooler spot. This was all quite obvious; it required no explanation but did you ever wonder about the invisible radiation that was emitted before the stove became red hot? You must have noticed that even before the stove turned red hot, you could feel the heat; you could not see anything, however. What really happened? If that which warmed you when the stove was black was heat, what

was it when it turned red? Are there different kinds of heat? Is black heat different from red heat?

To most of us ho have studied even the simple elements of physics these questions answer themselves. We know only too well that the heat from the black stove is not fundamentally different from that from the red hot stove except that at the latter stage it is more intense and that it affects our sense of seeing as well as of feeling. At the red hot stage, we learned at school that the radiation is of shorter *wave length* or higher *frequency*. Radiation, we were told, was largely a matter of frequency or wave length. We can see radiation of only certain wave lengths; specifically, only those wave lengths between 7700 and 3800 Angstrom units.[1] In other words, the eye is sensitive only to the wave lengths in this range. As we shall see all radiations can be expressed in terms of their wave length. Those lying in the range just below 3800 Angstrom units are called the ultra-violet radiations, because they lie just beyond the violet end of the spectrum. We can neither see nor feel the ultra-violet radiation but, as will be shown, they have very pronounced photochemical and photoelectric as well as biological effects.

Above 7700 Angstrom units are the infra-red, so named because they lie in that portion of the spectrum just beyond the red in the visible range. Our eyes cannot see the infra-red but we can feel them and in everyday experience we recognize them as heat. These are the radiations which the stove sends out before it becomes red hot.

Between these infra-red radiations and the ultra-violet, are the radiations which the eye can "see." It is true that when the stove is red hot we both feel and see radiation, but this is because there is a mixture of light and infra-red waves. If the latter are filtered out we will no longer feel the radiation coming from the stove but we will still see it.

The point we are trying to make clear here is that the mere changing of the wave length of radiation causes it to exhibit widely different effects. In Fig. 1 is shown a scale, known as the electromagnetic spectrum. It is nothing more than a scale representing the length of various kinds of electromagnetic radiation of which we have knowledge. It looks quite simple and is quite simple, yet in many ways it is a wonderful thing. Its length, or rather its growth, is very much a measure of the growth of man's scientific knowledge. At one time the only portion of it of which man had any knowledge was the small central portion labeled *visible light* and a portion of the adjacent region called the *infra-red*. For many centuries, indeed for the greater part of man's existence on earth, these were the only portions of this scale of which man had knowledge.

Later, and remember, all this occurred within the last hundred years, the existence of electric or "radio" waves was predicted and discovered. Next came knowledge of the X-ray and the gamma rays from radium and as each of these was studied they were found to fit into a definite place in the electromagnetic spectrum; they all appeared to be members of the same family. At first there were many gaps but these

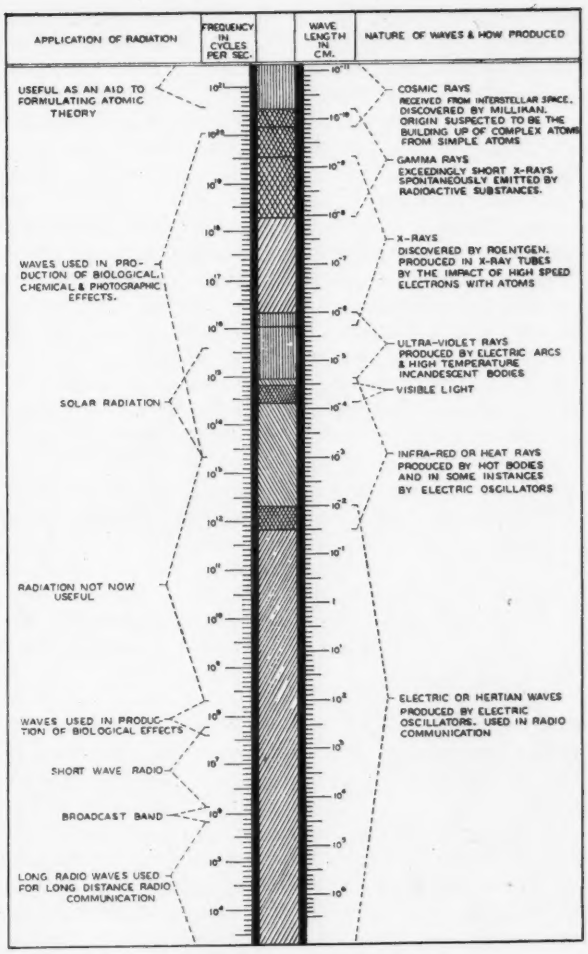

APPLICATION OF RADIATION
FREQUENCY IN CYCLES PER SEC.
WAVE LENGTH IN C.M.
NATURE OF WAVES & HOW PRODUCED
USEFUL AS AN AID TO FORMULATING ATOMIC THEORY
WAVES USED IN PRODUCTION OF BIOLOGICAL, CHEMICAL & PHOTOGRAPHIC EFFECTS.
SOLAR RADIATION
RADIATION NOT NOW USEFUL
WAVES USED IN PRODUCTION OF BIOLOGICAL EFFECTS
SHORT WAVE RADIO
BROADCAST BAND
LONG RADIO WAVES USED FOR LONG DISTANCE RADIO COMMUNICATION
COSMIC RAYS
RECEIVED FROM INTERSTELLAR SPACE, DISCOVERED BY MILLIKAN. ORIGIN SUSPECTED TO BE THE BUILDING UP OF COMPLEX ATOMS FROM SIMPLE ATOMS
GAMMA RAYS
EXCEEDINGLY SHORT X-RAYS SPONTANEOUSLY EMITTED BY RADIOACTIVE SUBSTANCES.
X-RAYS
DISCOVERED BY ROENTGEN. PRODUCED IN X-RAY TUBES BY THE IMPACT OF HIGH SPEED ELECTRONS WITH ATOMS
ULTRA-VIOLET RAYS
PRODUCED BY ELECTRIC ARCS & HIGH TEMPERATURE INCANDESCENT BODIES
VISIBLE LIGHT
INFRA-RED OR HEAT RAYS
PRODUCED BY HOT BODIES AND IN SOME INSTANCES BY ELECTRIC OSCILLATORS
ELECTRIC OR HERTIAN WAVES
PRODUCED BY ELECTRIC OSCILLATORS. USED IN RADIO COMMUNICATION

Fig. 1. The Electromagnetic Spectrum

have gradually been filled so that today we have practically a continuous scale extending from the infinitely short rays of radium, less than a hundred millionth of a centimeter in length to the very long radio waves of the transoceanic wireless stations, 20,000 or more meters in length. This entire vast range of lengths is represented by the scale in Fig. 1.

All of these radiations, light, X-rays, radio waves, were regarded as being vibrations or waves in a purely imaginary medium called the ether. No proof of the existence of an ether was ever shown but a wave had to be a wave in something and so the ether was invented. It served as a convenient explanation for the action of light, radio and X-rays. Just as a disturbance in water produces a wave which travels outward from the point of disturbance, so it was thought that a disturbance in the ether produced light waves or X-rays or radio waves. All of these waves, it was shown mathematically and experimentally, traveled at the same speed, at the rate of 3×10^{10} cm. per second, the velocity of light. The only difference between the waves of light and the waves of the X-ray or any of the other radiations, it was demonstrated, was in their length. And since the speed was constant, it was apparent that there was an inverse relationship between the wave length and the frequency of vibration; as the wave length becomes shorter, the frequency

[1] The Angstrom unit is the conventional unit for the measurement of wave length when dealing with light, heat, etc. It is the one hundred millionth part of a centimeter.

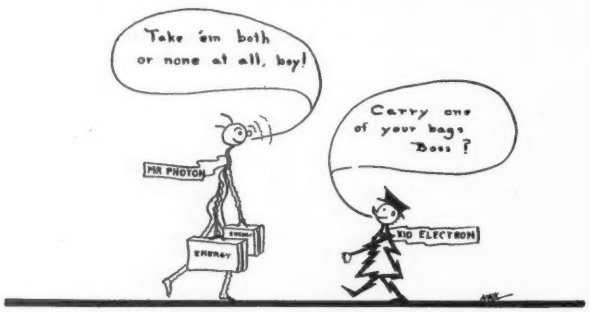
becomes greater and vice versa. In other words, the product of the frequency multiplied by the wave length always equaled the velocity of light, 3 x 10^{10} cm. per sec.

This wave theory served well; it explained the properties of light in a way that no other theory had been able to do before. On the basis of this theory light was a form of energy stored in the ether which traveled outward from its source, spherically, in all directions. The energy at any point in space varied as the distance from the source; the energy of the wave was less the further it traveled from its source, just as the circular waves which spread out from a stone dropped into a pond grow weaker as they spread out from the center. All this was quite simple and easy to understand, provided you could imagine the ether, which was not easy.

Now, we can return to our red-hot stove. As the stove turns from black to red, that is as the temperature rises, the frequency of the radiation increases and, conversely, the wave length decreases. Now, we know that as the temperature rises we get warmer and back away from the stove; we can stand or sit at a considerably greater distance and yet feel just as much heat. There seems to be more energy in the high frequency heat waves than in the lower frequency heat waves.

This, it can be demonstrated, is an actual fact. The total radiation coming from a stove or any such black body increases very much as the temperature rises, in fact it increases as the *fourth power of the absolute temperature.*[2] As early as 1880, Tyndall found that 11.7 times as much energy came from a platinum wire at 1200 deg. C. as from the same wire at 525 deg. C.

By breaking up the radiation from the stove into its separate wave lengths by means of suitable prisms and lenses and measuring the intensity of the radiation in these various wave lengths, it can be shown that the hotter the stove, the shorter the wave length and a set of curves can be drawn which illustrate this.



When a Photon meets an Electron it hands over all its energy or none at all

To plot such graphs and to demonstrate that this was true was one thing, but to account for it on the basis of purely theoretical considerations was quite another, and a great deal of effort was spent in trying to find an equation which fitted these graphs.

It was not until around 1900 that any success was had but then Max Planck finally succeeded. In doing so he made some radical departures from the accepted physical principles of the time. Until that time it had been thought that the energy given off from a hot body or from an incandescent filament was due to the incessant motion of electrons within the atoms. In other words, it was thought that an atom radiated energy continuously. (You, probably, are wondering what all this has to do with phototubes but, don't worry, we'll come to that.) Planck assumed that the atoms radiate energy *discontinuously,* in bundles, so to speak. An atom could release a whole bundle of energy but not part of a bundle. Furthermore, he gave the law by which energy is radiated under this assumption. It was

$$e\ (\text{energy}) = h\ v$$

where v is the frequency of the radiation, and h is a universal constant known now as Planck's Constant and is equal to 6.55 x 10^{-27} erg. sec. This law and this constant have since become quite famous and it has appeared in all sorts of rather unexpected places. It

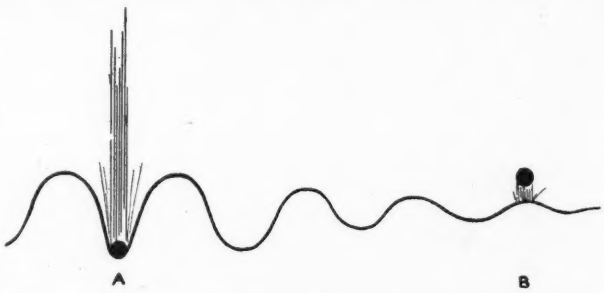


Fig. 2. A ball dropped into a pond at A creates a wave which ejects another ball floating on the surface of the water at B

is fundamentally connected with the mechanics of the atom.

In the meantime, the study of the photoelectric effect started in 1887 when Hertz found that the ultra-violet light falling on a spark gap enabled a discharge to pass more easily than when the gap was not illuminated. A year later Hallwachs made the important observation that while ultra-violet light falling on a negatively charged body caused a rapid loss of charge, no loss of electricity occurred when the body was initially positively charged. So the study went on and it was not long before the cause of the behavior was discovered. In 1899 J. J. Thomson and P. Lenard showed independently that the action of the light was such as to cause the emission of negatively charged particles—electrons. In some strange way, when light fell upon the surface of a solid body, electrons in that body "flew out."

Shortly afterwards, in 1902, in another series of investigations, Lenard opened up a new method of attack when he directed attention to the velocity of the ejected electrons. He was able to show that the maximum velocity of the ejected electrons was independent of the intensity of the light but that the velocity *did* depend upon the wave length or the frequency of the radiation.

To one familiar with the wave theory of light, this was a strange discovery. No wave theory of light could explain it and Lenard was fully aware of the difficulties of the situation when he announced his findings. He appreciated quite clearly the difficulties raised in the way of any explanation since the obvious

[2] This is known as Stefan's Law. It is expressed in the form of an equation as follows: E T^4 or E = a constant × T^4.

suggestion of the ejection being due to a transference of energy from the light to the atom of the metal by some sort of reasonance action was rendered impossible by its lack of dependence upon intensity.

On the basis of a wave theory, it is quite conceivable that if a ball is dropped into a pond as shown in Fig. 2 another ball floating on the surface of the water some distance away might be lifted upward by the waves reaching it. One would not expect this second ball to be lifted very high, however, especially if it were some distance away since it is quite obvious that the energy in the wave decreases rapidly with the distance from the original splash. Yet, in the photoelectric effect, the ejected electron *is* knocked out of the metal at *exactly* the same speed as the electron which

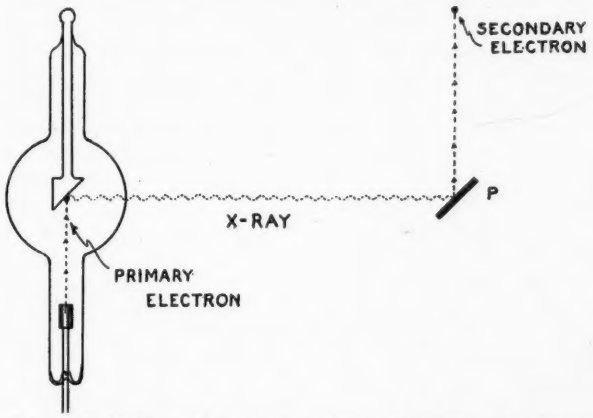


Fig. 3. In this X-ray tube, a primary electron traveling, say, at 25,000 mi. per sec. impinges on the target and produces an X-ray. This X-ray striking the metal plate P, ejects a secondary electron which also travels at 25,000 mi. per sec.

originally produced the radiation. In Fig. 3, for example, is shown an X-ray tube; in this tube a primary electron travelling say at 25,000 miles per second impinges on the target thus producing an X-ray. This X-ray is directed upon another metal plate outside of the tube where by photoelectric action it releases an electron (called secondary emission). Now, strange to say, this secondary electron will be ejected at exactly the same speed as the primary electron, i.e., at 25,000 miles per second. And this is true no matter how far the X-ray has to travel.

This is, indeed, a strange phenomena. It is the same as though a lifebuoy were dropped from a height of ten feet in New York harbor and the resulting wave travelling across the Atlantic lifted a similar lifebuoy 10 ft. out of the water at Brest, France. This sounds preposterous, does it not? Yet, that is exactly what happens in the case of the photoelectron. In the photoelectric effect, the speed of the ejected electron is always a function of the frequency of the radiation causing its emission.

It was this strange action which formed the basis of Einstein's famous paper in 1905 in which he suggested that the general phenomenon of the conversion of light energy could be better understood on the assumption that the energy of light radiation was not distributed continuously in space, as assumed by the wave theory. As radiation spread outward from a source he imagined it to remain localized in small bundles or energy *quanta*, which became further and further apart as they receded from the source while, individually, each bundle remained unchanged.

It is needless here to recount the subsequent experimentation in this field since Einstein's bold suggestions but all the work done since that time has only confirmed the validity of this idea. And it is on this basis that the photoelectric effect is explained today. Radiant energy (light, X-rays, heat, ultra violet rays, etc.), is assumed to consist of particles or quanta which travel through space, unchanged, undiminished in strength. When these light quanta encounter matter they give up either all of their energy or none at all. They cannot part with only a portion of the energy involved. The energy involved in these light quanta is a function of the frequency and as explained before is given by the expression $e = h\,v$ where h is Planck's constant and v is the frequency of the radiation. The light quanta are called photons.

The photoelectric effect, therefore, involves the interchange of energy between photons and electrons. And, because the energy of the photon is dependent upon the frequency of the radiation, the photoelectric effect also is dependent upon the frequency. This explains the color sensitivity of the phototube, since color is a manifestation of frequency. This, however, is a matter which will be discussed in a subsequent article.

We have endeavored here to present briefly some of the more important theoretical considerations which underlie photoelectric action. As pointed out earlier in this article, these facts do not have to be understood if one is only casually interested in the application of phototubes, but they provide a rich background for a more thorough appreciation of the action and the possibilities of photoelectric devices. In the next installment of this series we shall consider the effect of these principles upon the characteristics of the phototube.

Why Supercharge Diesels?

(Continued from page 355)

losses, the flow passages should be no smaller than those required for the optimum air-flow speed in the combustion chamber. The calculated air speed, 308 f.p.s., for these tests, was about 16 per cent less than the optimum for the 1500 r.p.m. tests.

At 2000 r.p.m. better engine performance was obtained at a calculated air-flow speed 5 times the linear speed of the crankpin rather than 8 times, which was optimum at 1500 r.p.m.

Increasing the inlet pressure decreases the ignition lag and consequently the rate of pressure rise in the cylinder, which results in increasing smoothness of operation.

In order to obtain power in proportion to the boosted induction pressure with the pressure-rise type of combustion, it is necessary that the maximum cylinder pressure be increased in proportion to the compression pressure.

Indicated mean effective pressures of 240 lb. per sq. in. and fuel consumptions of 0.30 lb. per hp-hr. have been readily reproduced during routine testing at 2000 r.p.m. and 20 in. of mercury boost pressure.

The Old Prize Fight Argument

Although a good, big man has the advantage of a good little man in the ring, a turbine designer undertakes to show that conditions are different in the turbine room and the 3600 r.p.m. David justifies strong financial backing when pitted against the 1800 r.p.m. Goliath

By NORRIS D. GOVE,

Design Engineer,
Westinghouse
Elec. & Mfg. Co.

DURING THE PAST YEAR there has been a remarkable advance of 3600 r.p.m. condensing turbine ratings into a field hitherto confined to units of half that speed. While the consolidation of that advance awaits a period of experience in operation only a few are so conservative as to doubt the wisdom of the move. The great majority of engineers have faith enough in their figures and confidence enough in the designers to approve the advance and have signified their convictions by investing millions of dollars during the past year in large 3600 r.p.m. condensing units. Out of this larger class a few without the backing, as yet, of any great number of their associates, feel that the large 1800 r.p.m. class of turbines must now justify their application or yield entirely to the higher speed units.

In the past there have been four major reasons for the use of the 1800 r.p.m. units in the central station field: Availability in required sizes; increased efficiency; lower unit cost; and previously allowed space in existing plants.

As regards size, several 3600 r.p.m. tandem condensing units are now being built for ratings from 25,000 to 50,000 kw. There would seem to be few systems where such units either singly or in multiple could not meet the requirements. If such there be, cross-compounding can be employed to extend these ratings without any particular complication of design, manufacture, or installation. This has been done before with 1800 r.p.m. units and is just as feasible with 3600. This is mentioned as a possibility, although it is not expected that the principle will have extensive use. The suitability of 25,000 to 50,000 kw. ratings on any large system seems reasonable when one considers the large systems utilizing several much smaller hydro-electric units.

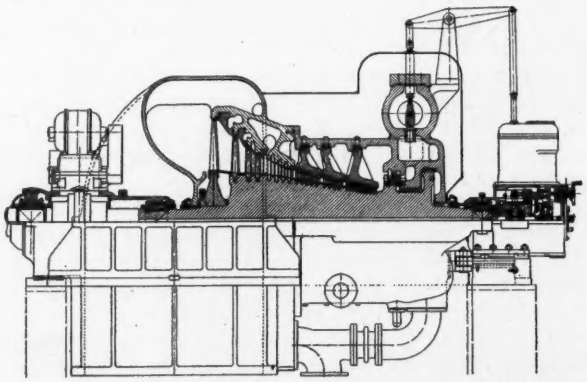
With respect to efficiency, the large 3600 r.p.m. turbines do not suffer by comparison with the slower speed units. A 25,000 kw., 3600 r.p.m., single cylinder unit, now practically completed, will have a heat rate equal to that of the largest 1800 r.p.m. turbine ever built, with only a slight advantage in the pressure range used. In the 1200 lb. class, a 3600 r.p.m. tandem now on order seems remarkably well selected for its purpose. For ratings as low as 20,000 kw. it is only necessary to select a reasonably good operating cycle to obtain heat rates below 10,000 B.t.u. per kw-hr. In the high temperature range it is widely believed that the smaller proportions of the higher speed machines render them more free from harmful distortions and the consequent decrease in efficiency.

The long-standing belief that "the larger the turbine rating the lower the unit plant cost" cannot be summarily disposed of. Perhaps it cannot be disposed of at all. The question of plant costs is so full of complex variables that it is almost impossible to draw general conclusions. A complete study of a large 1800 r.p.m. unit plant versus a 3600 r.p.m. plant with twice as many elements might be a valuable addition to our engineering literature. In such a comparison the larger units would have the traditional advantage of size. On the other side of the balance the following considerations would have weight: Lighter foundations; smaller crane, and shallower engine room and basement with generally lighter construction.

In calculating operating costs reasonable estimates of the following should have influence: Probable greater reliability of the smaller units; greater availability of the smaller units because of their greater number, and higher availability factor of the smaller units because of the shorter period required for inspection.

In existing 1800 r.p.m. plants, where a definite space has been left for another unit, usually the best plan is to continue the original schedule and install another turbine of similar proportions. An exception to this was found in one plant where a 25,000 kw., 3600 r.p.m. turbine is being installed in a place originally reserved for a 10,000 kw., 1800 r.p.m. unit. From exceptions like this, one is forced to conclude that any long continuing turbine project must be periodically rechecked to insure it against obsolescence.

About a dozen large 3600 r.p.m. condensing turbines are now on order in this country. The designers are confident that they will be found to be in no way inferior to their slower predecessors. They knew that equally high quality of design, material and construction prevails in each and some of them, at least, believe that certain inherent advantages favor the higher speed.



The largest single cylinder condensing turbine to date, a 25,000-kw. unit designed for 640 lb. ga., 825 deg. F.

In this article the author presents several interesting graphical solutions of electrical problems. The solution of parallel resistances is especially interesting since it is simple and accurate enough for all practical purposes. If you have not had much mathematics, don't let the equations presented scare you; they are really quite simple.

Graphical Methods in the Solution of Electrical Problems

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GRAPHIC METHODS are often useful in the solution of electrical problems, especially where the problems involve time displacement of voltages and currents. Some graphical methods are well known, others, applicable to certain type of problems are known only to those dealing more or less regularly with these problems. In the discussion which follows, the solution of some fundamental problems by graphical methods is demonstrated.

First we shall consider the determination of the equivalent resistance of a group of resistances connected in parallel. Little is known about this method and so it is presented in considerable detail.

In the second part on impedances, it is assumed that the reader has some fundamental knowledge of the principles of alternating current and some information has been sacrificed for the sake of brevity.

The first problem, for the determination of the equivalent resistance of a group of resistances in parallel, is solved as follows:

Draw three lines (Fig. 1) WX, Z, and Y making angles of 60 deg. with respect to each other. Let R_1 and R_2 denote the first and second resistances connected in parallel. Measure R_1 along the line OX (O being the intersection of the three lines) to a point A. Then measure R_2 along line OZ to a point B and connect the points A and B with a straight line AB.

The length of the line OC, measured to the same scale to which R_1 and R_2 were measured, will represent the equivalent resistance of the parallel resistances R_1 and R_2. To prove this we shall use the following notation:

$$OA = R_1$$
$$OB = R_2$$
$$OC = R$$
$$BC = m$$
$$CA = n$$
$$\text{angle at } A = \alpha$$
$$\text{angle at } B = \beta$$

Then from triangle OCA, by the law of sines, we have the following relation:

$$\frac{\sin \alpha}{R} = \frac{\sin 60^\circ}{n}$$

From triangle OCB we also have the relation:

$$\frac{\sin \beta}{R} = \frac{\sin 60^\circ}{m}$$

From triangle OAB we have these relations:

$$\frac{\sin \alpha}{R_2} = \frac{\sin 120^\circ}{m+n}$$

$$\frac{\sin \beta}{R_1} = \frac{\sin 120^\circ}{m+n}$$

Eliminating m, n, α, β, from these relations, the eliminant relation is:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

or

$$R = \frac{R_1 R_2}{R_1 + R_2}$$

which is the value of the resistance in the parellel combination.

Now measure the resistance R_3 to the point D on the line OW:

$$OF = \frac{1}{R_3} + \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

which is the equivalent resistance of three resistances connected in parallel.

It is evident that this process can be extended to any number of resistances connected in parallel.

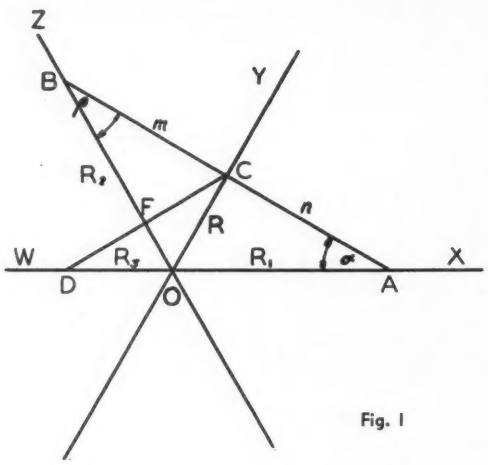


Fig. 1

Next we shall discuss the problem of the determination of the equivalent impedance of a group of impedances connected in series.

Let X_L (Fig. 2) denote the inductive reactance of a circuit. X_C is the capacity reactance in the circuit. R is the resistance in the circuit.

From fundamental considerations it is known that RI is the resistance drop, which is numerically equal to the portion of the impressed electromotive force necessary to overcome the resistance of the circuit in order to establish current I.

RI being in phase with the current, $X_L I$ is the inductive reactance of the circuit, which is numerically equal to the portion of the electromotive force impressed necessary to overcome the inductive reactance of the circuit. This electromotive force leads the current by 90 deg. Similarly $X_C I$ represents the capacity drop which is numerically equal to the portion of the electromotive force impressed which is necessary to overcome the capacity reactance of the circuit. This electromotive force ($X_C I$) lags behind the current by an angle of 90 deg.

Let us now draw a line OA to represent the current I drawn in the circuit. In phase with the line OA we draw line OB which represents the RI electromotive force. From the point O we draw line OD to represent the $X_L I$ electromotive force 90 deg. from OA and in the leading direction. From O we draw the line OC which represents the $X_C I$ electromotive force 90 deg. behind OA or in the lagging direction. The resultant of the three vectors OB, OD, OC, is OE which represents the value of the electromotive force required to overcome the resistance, inductive reactance, and capacity reactance in order to establish an alternating current I.

$$OE = \sqrt{OB^2 + OF^2} \qquad OD = X_L I$$

(from figure) $OF = OD - OC \qquad OC = X_C I$

moreover $OB = RI$

$$\text{therefore} \qquad E = \sqrt{RI^2 + (X_L I - X_C I)^2}$$

$$\text{or} \qquad \frac{E}{I} = Z = \sqrt{R^2 + (X_L - X_C)^2}$$

in which Z is the impedance in the circuit.

The rule, therefore, is to measure a line to represent the resistance and at right angles with that line to measure another line to represent the difference of the inductive reactance and the capacity reactance. Complete the right triangle. The hypotenuse represents the impedance of the circuit in ohms. If a group of impedances connected in series as given and the resistance and reactance of the circuit are also known, measure the sum of the resistances on a straight line and the algebraic sum of the reactances on a line perpendicular to the latter. The hypotenuse of the right triangle thus formed is the resultant impedance, as it would be evident from the figure, (Fig. 3).

Impedances in parallel:

When a group of impedances, Z_1, Z_2, Z_3, Z_n are given and the resistance and reactance of each impedance is known, the resultant or equivalent impedance can be found as follows:

Draw a line OD (Fig. 4) to represent the voltage impressed in the circuit and draw a circumference of a circle with OD as diameter. Draw a line making an angle whose tangent is R_1/X_1, with the impressed electromotive force E to point A on the circumference of the circle. This angle is θ_1. Then OA/R_1 will give as the value of the current I_1, the current of the first branch. (R_1 is the resistance of the first impedance.) Draw a second line OB making an angle θ_2 whose tangent is R_2/X_2 with the impressed electromotive force. Then OB/R_2 will give the current I_2 in the second branch of the parallel combination. This process can be carried out to n branches.

Considering the two currents thus obtained we will determine the resultant current by completing the parallelogram and drawing the diagonal OI, which is the resultant current I. This current cuts the circuit at the point C. OC therefore represents numerically the resistance drop. Hence $OC/I = R$, equivalent resistance of the circuit. Also the line CD, which represents the numerical value of the equivalent resistance drop, when divided by I will give the reactance X. ($X = CD/I$) X and R represent the equivalent resistance and reactance of the circuit which will have in it the resultant current I when an electromo-

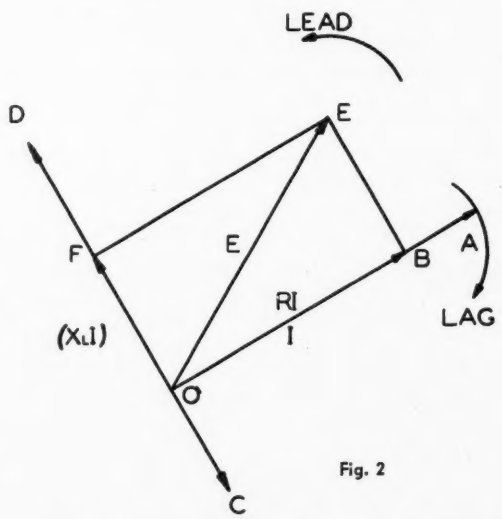
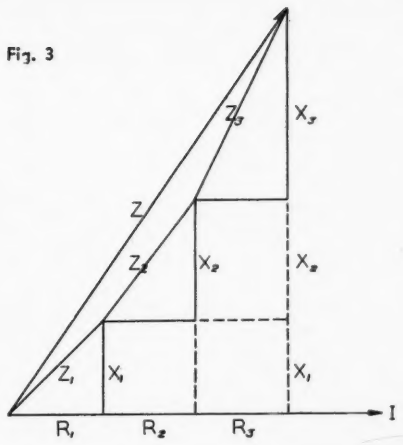


Fig. 2

Fig. 3



tive force E is impressed at its terminals. The equivalent impedance is therefore given as $\sqrt{R^2+X^2}$. It must be noted that X is in this relation equal to $X_L - X_C$, wheh is the algebraic difference of the inductive reactance and the capacity reactance which will be considered as positive if X_L is greater than X_C in which case the current lags behind the electromotive force by an angle whose tangent is X/R.

$$\tan^{-1}\frac{X}{R}=\frac{X_L-X_C}{R_1}$$

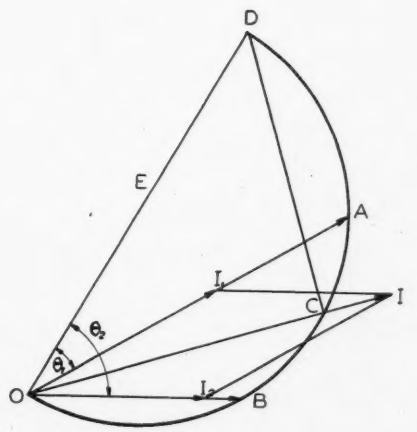


Fig. 4

$$\theta_1 = \tan^{-1}\frac{R_1}{X_1}$$

$$\theta_2 = \tan^{-1}\frac{R_2}{X_2}$$

If, however, the capacity reactance predominates, the current will lead the electromotive force in the circuit by:

$$\tan^{-1}\frac{X}{R}=\frac{X_C-X_L}{R_1}$$

Principles of Furnace and Heat Trap Design

By Pulverizer Pete

I SEES WHERE you publishes my first article which I sends you, Ed., and thinks your drawings is swell too. But I don't like how you draws wiskers on my face because I got one of these electric, no soap, razors and uses it almost every other day. It's funny but I busts the plug on this thing so now I now I wraps the wire around a couple of bare nuts behind the switchboard. This works right good but it seems every time I shaves pretty soon the engineer he comes down and starts raisin' hell because the ink line on one of them recording meters has got a lot of bumps in it what shouldn't ought to be there.

It also looks like I drums up some business because one guy who sees my article wants me to design him a superheater for a circus calliope. Another fellow wants I should figure out a separately fired desuperheater for him. Maybe you can help me with that one.

I suppose you wonders why I tells you about turbines this month when I really should stop last month when I finishes the last heat trap like the title says. But I guess you ought to know what to do with the swell steam I shows you how to make.

Probably you want to make electricity so you better get or make a turbine connected to a dynamo. A turbine ain't nothing but a bunch of windmills on a rod inside a tin can but I saw one apart once so maybe you better buy it instead of build it.

You connect this with your boiler with a hose or pipe. A hose is best, for you can just squeeze it in a vise to cut off the steam.

Now everything is ok except when you gets to about the middle stage of your turbine the steam begins to get very wet which is not so hot. Now if your steam was hot enough when you started this wouldn't happen but it happens so some engineers takes the steam out of the turbine, puts it through a reheat boiler and then takes it back. Now I saves a lot of trouble because I puts the last stages of the turbine on the furnace so the steam gets reheated right in the turbine. Then I connects this parts of the turbine to the other with a flexible shaft. So now you got a darn fine power plant except you need some controls and meters. To get these you just take apart an old radio and stick a lot of switches, vacuum tubes and rheostats around the place and you is all set.

We has a young kid around here once what says he learns all about how to use radio tubes from your magazine so the chief he lets him fool around.

Which is ok until one day the chief comes down to check the alternators on the cathode ray tube when he gets a television picture of Joan Crawford opening a new Diesel plant which he hates (I mean the Diesel plant). So he grabs the telephone and gets a radio speech by a guy cussing fly ash and smoke, and so we now ain't got a kid what knows all about radio tubes.

Now the next time you needs an article, Ed., you knows where to get it so just let me know and I will probably gets another idea.

In Gas Welding and Cutting, why is Acetylene so universally used? What is the reason for its superiority in this respect over other Gases? These questions are answered in this article, which is a part of the first of a series of lectures on welding presented by the New York Section of the American Welding Society.

What Happens During Welding and Cutting

By Dr. George V. Slattman
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GAS WELDING AND CUTTING are processes which require the maintenance of a relatively high temperature at the surface of a material of high thermal conductivity. In steel welding, for example, the steel surface must be heated to the melting point, 2750 deg. F. The heat of fusion supplied to melt the surface and the resulting liquid superheated some hundred degrees Fahrenheit to secure sufficient fluidity to permit mixing with the molten metal from the welding rod. In steel cutting the temperatures necessary are somewhat lower, but here also the steel surface must be brought to the ignition point with oxygen, some 1500 deg. F.

In both welding and cutting the problem of distortion requires that the heat be confined as far as practicable to the metal surfaces to avoid heating large masses of the base metal and further from a cost standpoint, confining the heating to the surface of the material reduces the amount of material to be heated and permits of high speed of operation.

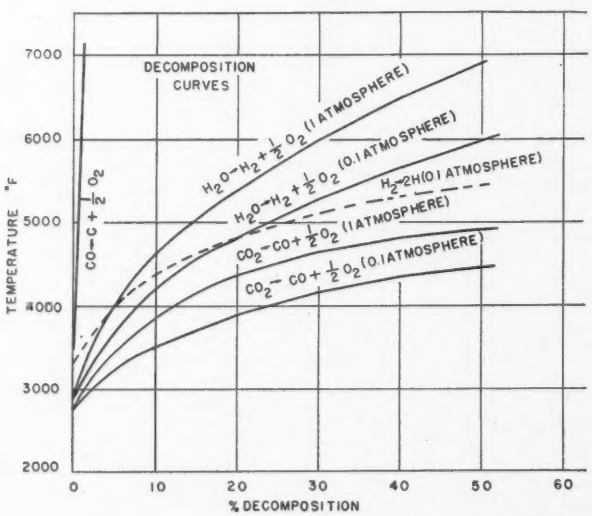


Fig. 1. The percentage decomposition of the reaction products of common gaseous combustions, carbon monoxide, carbon dioxide, water vapor and molecular hydrogen

In order to maintain a sharp temperature gradient between the surface and interior of a highly conductive material such as steel, a high temperature heat source and conditions favorable to a high rate of heat transfer from that source to the object heated must be maintained. Since the thermal conductivity of the object to be heated has a fixed value, the rate at which it can be heated and at which the heat of fusion necessary for melting can be transferred will depend upon the temperature of the heating flame, and on the specific rate of heat transfer through the boundary layer flame to the object, the latter depending upon a number of factors including luminosity of the flame, flame speed, and thermal conductivity of the flame gases. A further characteristic is required of the heating flame, especially in steel welding. The products of combustion which bathe the surface of the molten steel puddle must protect the steel from oxidation by the air, and must in themselves be non-oxidizing and for certain classes of steel welding, actually reducing in character.

Flame temperature is easily calculated by striking a balance between the heat of combustion and a function of the specific heat of the products of combustion, the volume of the product of combustion and their increase in temperature, the latter being substantially the flame temperature. Combustion in air requires that for each volume of oxygen consumed, roughly, four volumes of inert nitrogen must be heated to flame temperature. With gaseous combustion in air, flame temperatures are relatively low, around 3000 deg. F., and such flames are inadequate for the rapid local heating of metals. With such temperatures the heat is carried away more rapidly than it can be supplied to bring the area to be welded to a sufficiently high temperature to cause melting.

By using oxygen instead of air, flame temperatures as calculated would be in the order of 10,000 deg. F. were it not for the fact that above 3000 deg. F. such

ordinarily combustible gases as hydrogen and carbon monoxide are increasingly difficult to combine with oxygen. Thus the reaction of oxygen and hydrogen to form water is not only incomplete but the normally stable hydrogen molecule is broken into its constituent atoms in a reaction absorbing heat from the flame and limiting its temperature. This breaking up of the hydrogen molecule is known as dissociation.

In Fig. 1, the percentage decomposition of the reaction products of common gases of combustion,—carbon monoxide, carbon dioxide, water vapor and molecular hydrogen,—are given for temperatures from 3000 to 7000 deg. F. and for partial pressures of 0.1 and 1 atmospheres.

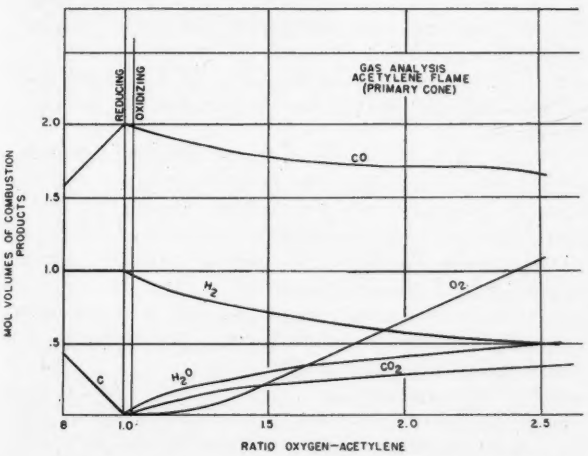


Fig. 2. Gas analysis of the primary combustion cone of the oxyacetylene flame for varying ratios of oxygen to acetylene

The higher the temperature and the lower the percentage of any constituent in the flame composition,[1] the greater the percentage decomposition of its combustion product, and conversely, the smaller the percentage of it that will unite with oxygen and liberate heat of combustion to increase the flame temperature. It might be thought that increasing the oxygen content of the flame might result in an increased temperature. This, however, is not true. Increasing the oxygen content of the flame by increasing the ratio of oxygen to fuel gas fed to a torch, decreases the dissociation of the combustion products and liberates more of the heat of combustion. A point is soon reached, however, where this waste heat of combustion is insufficient to heat the oxygen added to flame temperature, and the addition of further oxygen actually cools the flame, the flame meanwhile becoming increasingly oxidizing in character to a point where it is useless for steel welding.

Gases such as hydrogen and the saturated hydrocarbons, methane, ethane, and propane,[2] when completely burned with oxygen, give maximum flame temperatures in the order of 5000 deg. F., at which point they are extremely oxidizing in character. To maintain a reducing atmosphere with these gases a lower oxygen gas ratio must be used which reduces their flame temperature to a point where they are uneconomical for welding the higher melting metals because of their very slow rate of heating. The unsaturated hydrocarbon, acetylene, whose commercial availability marked the beginning of modern technique of gas welding, has the property of generating an extremely high temperature in the order of 6000 deg. F. in a reducing atmosphere, offering at once the advantage of high speed of operation and the ability to produce unoxidized weld metal of considerable ductility.

[1] Expressed as the partial pressure of that constituent.

[2] There are the major constituents of city gas, natural gas and the petroleum distillates.

Why Is Acetylene so Suitable for Welding and Cutting

Acetylene is chemically known as an endothermic compound. In its manufacture from calcium carbide, formed at high temperature in the electric furnace, it has absorbed energy in its molecular structure which can be released without combustion by the breaking up of this structure into its constituent elements. The heat of combustion of the carbon and hydrogen in a cubic foot of acetylene is 1205 B.t.u. The endothermal heat is 228 B.t.u., giving a combined value of 1433 B.t.u. per cu. ft. A saturated compound such as propane may be calculated to have a heat of combustion of its constituent carbon and hydrogen of 2475 B.t.u. per cu. ft. Upon combustion, however, only 2309 B.t.u. can be liberated, 166 B.t.u. being absorbed in breaking up the compound which is therefore known chemically as exothermic. In the case of acetylene the heat sup-

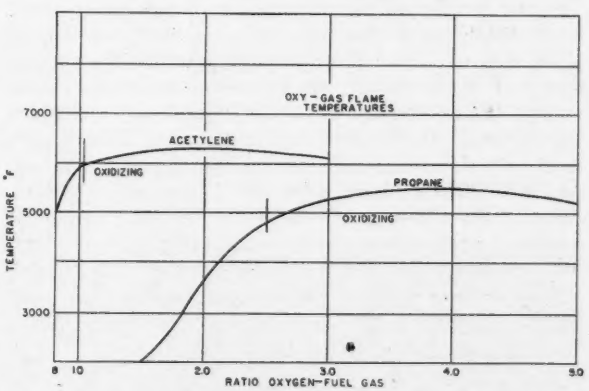


Fig. 3. Comparison of the flame temperatures of oxyacetylene and oxy-propane at varying oxygen fuel gas mixing ratios

plied during its manufacture is released upon combustion. In the case of propane the heat produced during its formation has to be returned during its dissociation. The effect of the endothermal heat of acetylene is to preheat the products of the molecular decomposition to a temperature of roughly 2000 deg. F., from which point a further increase in flame temperature is produced by the partial liberation of the heat of combustion. It is obvious, therefore, that very high temperatures can be produced with acetylene at low ratios of oxygen to acetylene. With saturated hydrocarbons which absorb some of the heat of combustion a more complete combustion is necessary to develop a high flame temperature resulting in an oxidizing flame. In Fig. 2 the gas analyses of the primary combustion cone of the oxacetylene flame are given for

varying mixing ratios of oxygen to acetylene. The flame, as will be noted, is strongly reducing below an oxy-gas ratio of 1.05 to 1 and shows little free oxygen at ratios as high as 1.2 to 1. Fig. 3 is a comparison of the flame temperatures of oxyacetylene and oxypropane at varying oxygen fuel gas mixing ratios. At no point is the propane flame strictly reducing and above a mixing ratio of 2.5 to 1 the flame is strongly oxydizing. A comparison of the flame temperatures corresponding to the reducing flame state for the oxyacetelene and oxypropane flame explains the pre-eminence of acetylene over other available commercial gases for welding. Sporadic attempts are made to use gases other than for welding because of their lower cost per cubic foot, but such attempts are doomed to failure because of the differences in the physical properties of these gases as compared with acetylene.

As commonly used for welding, the oxyacetylene flame is produced from the combustion of a mixture of one volume of oxygen and one volume of acetylene. The combustion products of this mixture, as seen from Fig. 2, consist of carbon monoxide and hydrogen. The carbon monoxide is very slightly dissociated into carbon and hydrogen while the hydrogen is undoubtedly considerably dissociated into its atoms. This combustion takes place in a very narrow cone surrounding the acetylene orifice of the welding tip and produces a temperature of roughly 6000 deg. F. at that point. An intensely luminous blue cone results, which is the active principle of the flame. The carbon monoxide and hydrogen leaving this cone combine with air oxygen and produce a voluminous low temperature flame surrounding an active blue cone, commonly called the sheathe flame. Due to its low temperature the sheathe flame is of secondary importance to the blue inner cone. By varying the ratio of oxygen to acetylene the inner flame can be made more strongly reducing or more oxydizing in character. Oxyacetylene ratios as low as 0.97 to 1 are used for backhand or speed-welding on pipe. Oxidizing ratios up to 1.2 to 1 are used for certain brass and bronze welding operations. The oxyacetylene flame is thus capable of producing a temperature of over 6000 deg. F. coupled with extraordinary flexibility in regard to the oxydizing or reducing properties of the flame.

Modern Industry

EIGHT HUNDRED AND FORTY tons of vacuum refrigeration is installed in one side of the boiler room of the Firestone Tire & Rubber Co. plant in Los Angeles to chill water for process while giving optimum heat balance conditions. The return water from process is cooled in an atmospheric cooling tower as low as prevailing atmospheric conditions permit and is then chilled in the vacuum refrigeration unit. This is designed to cool 2000 g.p.m. of water from 70 to 60 deg. F.

This Foster Wheeler unit is of the multiple-compressor design using high and low pressure steam. Four of the six steam jet compressors are operated with steam at 5 lb. gage and produce 504 t. of cooling effect. The two high pressure compressors operate with steam at 125 lb. gage and produce 336 t. of refrigeration. The six compressors are mounted on a divided flash chamber and discharge into a common surface condenser.

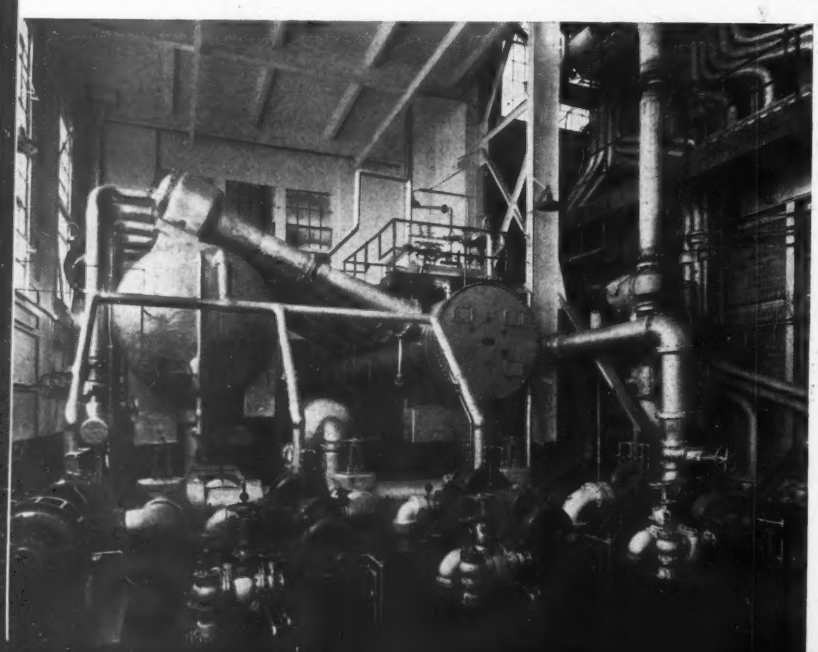
Three chilled water pumps are installed, each designed to handle 1000 g.p.m. Two of these are used for normal operation and are turbine driven, while the third unit, used as a spare, is motor driven. Only one condenser circulating pump, and that turbine driven, is installed. Duplicate, motor driven condensate pumps are provided for removing condensate from the main condenser and for pumping through the steam jet air pump to the feedwater system.

The flash chamber is divided into six separate compartments in order to permit part load operation. This design eliminates the use of large gate valves, otherwise required at the suction of the compressors. The design used consists of an inlet weir type distributing system and outlet seal tail pipes, which seal the various operating and non-operating compartments.

No water valves, with the exception of a float-controlled inlet valve, are used. Load changes are obtained by opening or closing the steam valves to the compressors. Condensate from the condenser is used as feed water for the high pressure boiler and baffles are installed in each compartment to minimize carry over of the chilled water with the flashed vapor.

As the proper operation of a vacuum refrigeration unit depends to a large extent upon the quantity and temperature of the cooling water furnished to the surface condenser, a large atmospheric cooling tower was furnished as part of the cooling cycle. The tower was selected of liberal size to assure satisfactory operation even with extremely low wind velocities.

Previous experience has shown that this is necessary if the full cooling capacity of the vacuum refrigerating unit is to be obtained under adverse atmospheric conditions. The duty of the cooling tower is to cool the circulating water of the condenser from 102 deg. F. to 80 deg. F. and this it does at the rate of 3420 g.p.m.



Vacuum refrigeration installed at one side of the boiler room in the Los Angeles plant of the Firestone Tire & Rubber Co., uses both high and low pressure steam

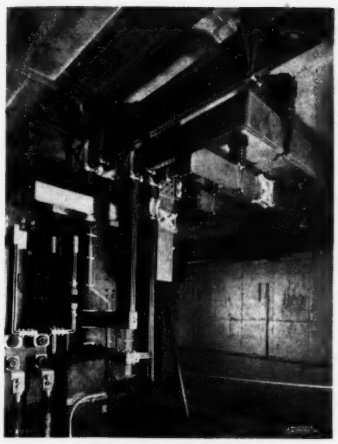


Fig. 1. Flat bus bars carry d.c. from the mercury arc rectifier to the 15½-ton copper channel bus

Power Application in New Wire Mill

Republic Steel Corp. employs electro-galvanizing process in coating copper-bearing steel wire in South Chicago

FORMAL dedication of the new wire mill built by Republic Steel Corp. in South Chicago took place April 27 in the presence of a large group of invited guests and officials of the Corporation, including the president, R. J. Wysor and Thomas M. Girdler, chairman of the board of directors. This wire mill, engineered and constructed by the Austin Co., puts into practical application results of extensive research carried on to determine proper specification and application of the steel products on the farm. With a process for making wire that is new in many respects, much of the equipment was specially designed and built to be automatically controlled by electrical devices incorporating the most modern features, giving a continuous production throughout an area of 177,000 sq. ft.

All electric power is secured through service lines from the public utility and the application in the mill has a number of unique features. In deciding upon the electrical equipment, only the types that would give a high degree of reliability with low maintenance costs were selected. An example of this is cited in the motor selections. Line start, three phase motors were used where possible. In the cleaning room, on conveyors and door lifts, high torque line start induction motors fully enclosed with acid proofed windings and ball bearings were used. Cast-iron switch cases and control housings with gasketed doors were also selected for use in this locality where acid fumes are so damaging to electrical equipment.

Totally enclosed ball bearing line start induction motors were selected for pointer and hoist motors in the drawing room to prevent lime dust from causing frequent cleaning of rotors.

Induction motors were used throughout the entire

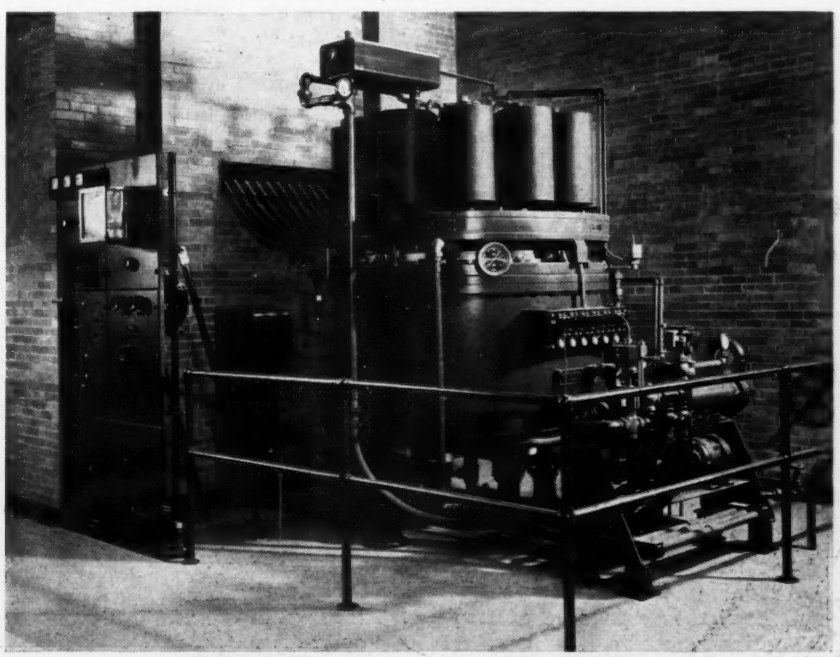


Fig. 2. For the first time in the history of America's iron and steel industry, a mercury arc rectifier is being used to provide the direct current

nail mill. Individual motor drive on the nail tumblers were used instead of line shaft drive with clutches for each tumbler. With the exception of one motor, all starting equipment in the nail mill is of the line start type, push button operated.

Machines requiring smooth acceleration and large speed ranges were equipped with direct current motors. Examples of these are found in the continuous wire drawing machines, galvanizing and patenting take-up frames, rod storage and cleaning room cranes.

Throughout the entire mill all important concentrations of electrical control are either found in the tunnels or on elevated platforms, leaving the floors for process material movements free from obstruction by control apparatus.

Mercury Arc Rectifier

Direct current supply, for the first time in any steel and wire mill in the Western Hemisphere, is furnished by a mercury arc rectifier, having automatic voltage control by means of electrically energized grids. This 1000-kw. rectifier is connected to the d.c. bus through a high speed breaker. The bus is a 9-in. copper channel ½ in. thick, mounted on special insulators and steel beams in the upper part of the connecting tunnels below the mill floors. This bus is at present the largest section of this type ever rolled. It was selected for strength and ease of installation. It is provided with expansion joints at proper intervals and carries d.c. power through the important distribution centers instead of bringing each feeder back to a centralized board. Circuit breakers for remote centers are tapped to this bus in the tunnel. The wire drawing machine control panels are mounted in the tunnel under the machines and adjacent to the bus. Voltage is maintained at load center of this bus by bringing two pressure wires from load center back to the rectifier voltage regulator in the power substation.

In the substation are located the mercury arc rectifier for d.c. conversion, transformers for three phase power, and the steel clad cubicle switchgear for high tension distribution.

The transformers are of a recently developed type in which inflammable and explosive oil used for cooling is replaced by a non-inflammable, non-explosive material. Losses are slightly lower in this transformer than in conventional types.

Power and lighting transformers in the new wire mill represent the first installations of this type in the Chicago area. The steel clad cubicle switchgear distribution center located in the substation represents the latest in this type of equipment, the oil circuit breakers being of 250,000 kv.a. interrupting capacity, push button operated, battery trip. Ample provision for growth of the wire mill is included in the switchgear installation. At present it consists of six important circuits as follows: one incoming line with 2000 amp. circuit breaker, two 1200 amp. and three 600 amp. feeder circuits leaving the cubicle.

Galvanizing Current

The electro-galvanizing setup includes six motor-generators, the two flash cleaners being small sets with 20-hp. driving motors and the four plating m.g. sets having 200-hp., 2300 v. three-phase synchronous motors, and 20,000 amp., 7-v. generators. Special 20,000 amp. shunts were built to furnish the necessary voltage drop for operating, recording, and indicating ammeters at the control station.

The control station in the galvanizing department consists of control push button stations for starting and stopping all m.g. sets, circulating pumps and take-up frame motors. Rheostats are located here for control of current output for the m.g. sets and speed of the take-up frames. Feet per minute of wire drawn through the plating bath is recorded on electrical tachometers mounted on the control station board. Indicating voltmeters and ammeters are mounted on the individual motor-generator control panels. Recording ammeters are mounted adjacent to the tachometer recorders. These recording instruments give the wire mill superintendent a constant check upon the entire galvanizing operation.

Lighting throughout the mill is supplied from a bank of transformers located centrally to load in a vault connecting with the main tunnel under the mill floor. Three phase, four wire distribution to the various lighting panels leaves this vault. The latest type of high power voltage fuses protect these feeders and are mounted adjacent to the transformers. Intensities in the drawing room are approximately 12 foot-candles, cleaning room 10 foot-candles, warehouses 5 foot-candles, galvanizing 8 and 14 foot-candles, and nail mill 12 to 15 foot-candles.

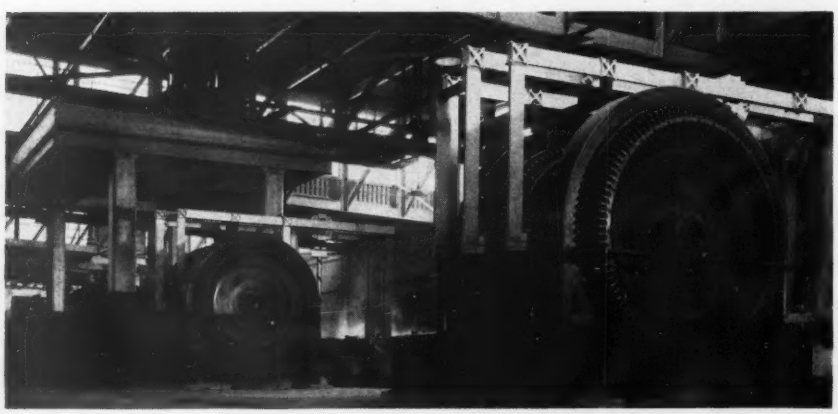


Fig. 3. Four motor generators of 15,000 amp. each provide current for the huge electro-galvanizing unit. This unit turns out fence wire with 27 coatings of pure zinc, at the rate of 578 mi. a day

Approximate footage of principal electrical materials used in the new mill is as follows:

Conduit, all sizes totals 55,000 ft., 4-in. being largest size used; transit conduit 14,750 ft., principally 3½ in. size in 10-ft. lengths for present and future underground feeder circuits to new wire mill; 600 v. wire and cable 185,000 ft. 6000 ft. of this being 500,000 circular mil size, and 6368 ft. of three-conductor 600,000 circular mil varnished cambric and lead 3000 v. cable.

Galvanizing Process

This mill has been provided with electro-galvanizing equipment in which the most recent achievements of electro-chemistry, metallurgy and industrial engineering have been combined to provide a continuous unit which is approximately 500 ft. from end to end. It is equipped with 80 payoff reels to facilitate continuous operation on the electro-galvanizing line, which has a capacity of 40 strands of wire. Coils transferred from the wire drawing or storage rooms on skids by electric lift trucks are placed on the payoff reels by two tramrail hoists.

After normalizing in a pot of molten lead, as in hot galvanizing, the wire is allowed to cool and passes over sheaves into the cleaning tanks which extend for a distance of 70 ft. The wire passes first through a hot alkaline bath which removes all surplus dirt; then through a water rinse and into the pickle tank, where remaining surface impurities are attacked by acid. After another rinse, minute particles still present in the pores and structure of the steel which might prevent a perfect bond are eliminated by passing the wire through an electrolytic flash cleaner, which etches the surface to provide for firm adhesion of the zinc coatings. After another rinse and a final acid dip it then passes through a final rinse into the electro-galvanizing tank. Large rollers hold the strands beneath the surface of the successive solutions and they are kept in line by porcelain sleeves on dividing walls between the various tanks.

Current Density

The electro-galvanizing tank is 140 ft. long, 6 ft. wide and 2 ft. deep. It requires approximately 43,000 gal. of special galvanizing solution, which circulates in the direction opposite to that of wire travel, passing through filters, three 10,000 gal. settling tanks and a cooling tower. Thirty tons of zinc anodes are immersed in this solution in the bottom of the electro-galvanizing tank as the wires, which function as cathodes, pass through it a little below the surface of the solution at speeds ranging from 35 to 70 ft. per min., depending upon the coating to be applied. The character of the special electro-galvanizing bath makes it possible to deposit 27 successive, even coatings of zinc 99.9 per cent pure upon the copper-bearing steel wire at current densities up to 1500 amp. per sq. ft., without developing either pores or pits.

The wire passes out of the tank with its coating already dense and bright. It is merely dipped into a cold rinse to remove adhering solution from the galvanizing tank, then into a hot rinse to remove any final traces and to heat the wire so that, when it enters the air, for winding on the take-up reels, any remaining water will dry quickly. With the coating thickness determined by the flow of current and speed at which the wire passes through the tank, the operator merely sets the speed of the reels and the rheostats of the generator circuits to a setting specified for each desired coating, to insure a uniform, even deposit on the wire.

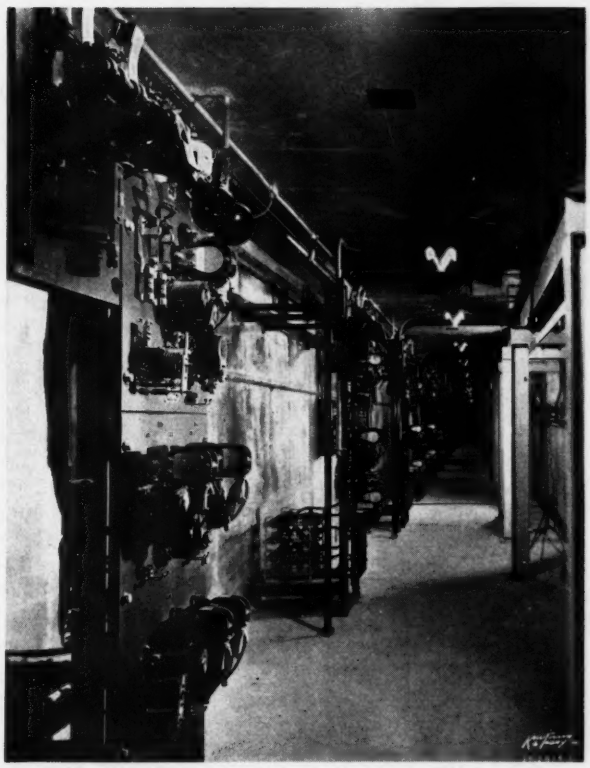


Fig. 4. All important concentrations of electrical control are found either in sub-floor tunnels, like this which serves the wire drawing room, or on elevated platforms.

The takeup frame consists of three separate units, two of these units having fourteen 22-in. blocks each, and one unit twelve interchangeable 16 or 22-in. blocks. Each of these units is separately driven by variable speed motors.

Exhaust Systems

The American Standards Association, 29 West 39th St., New York City, has released a report on fundamentals relating to the design and operation of exhaust systems. While the occupational disease problem is partly a medical one, the matter of minimizing exposure to poisonous dusts, gases, and fumes is purely an engineering problem and includes the important problem of installing exhaust equipment that will carry off the toxic dusts and gases present in certain industrial processes such as rock drilling and spray painting. Different types of dusts and gases require different treatment. Yet there are certain fundamental engineering principles common to the control of all. It is these basic engineering principles that the committee deals with in its report.

A.S.M.E. and the Automobile

Semi-Annual Meeting of the Society held in Detroit May 17 to 21 filled with technical papers dealing with all phases of mechanical engineering.

DETROIT members of the American Society of Mechanical Engineers again demonstrated their mastery of hospitality by entertaining visitors to the Semi-Annual Meeting of the Society. This city, which has cradled the automobile industry to the point where it is a dominant factor in the industrial life of the nation, has contributed a vast amount of technical information to the engineering profession that has permitted nearly all industries of the country from agriculture and mining to heavy machinery manufacturing and precision instrument making. These contributions to the mechanical engineering profession growing out of the development of the automobile industry formed the nucleus around which the program for the meeting was built and interest was maintained by inspection trips to many of the leading factories and power plants of the city.

Dr. C. F. Hirshfeld in delivering the keynote address of the meeting made the following pertinent remarks: "We of Detroit are just a little proud of certain phases of our engineering and industrial development and we think we are justified in our pride. We believe this community has exerted a very definite and beneficial leadership in the evolution of many admirable features of modern industry. We believe we have put into practice, and proved to a great extent, rather novel principles of great human worth. We believe we have indicated to a measurable degree the paths to be followed by industry in advancing toward the maximum of both economic and social values."

From among the many papers presented at this meeting only those dealing with power plant subjects have been selected for brief abstracting here, several of these are considered of such value, however, that they will be published almost in entirety in later issues of this magazine.

Various problems and engineering studies made in connection with the design and construction of a large modern water works plant were discussed by William C. Rudd and Bernard J. Mullen, with special reference to the hydraulic and mechanical features of the pumping plant, Springwells Station of Detroit, and the mechanical and electrical characteristics of the steam-operated power plant. The pumping plant consists of raw water pumps for delivering river water to the filter plant and also the filtered water pumps to supply water to the city distribution system. Power for the pump motors is produced in a steam turbo-generator plant, exclusive of a small portion which is secured from a central station source.

Fuel Problems

Size-frequency analysis of cinders and fly ash, and the variation of the efficiency of dust separation with varying dust particle size were dealt with by Arthur C. Stern. He showed how these two factors may be combined to determine the overall efficiency of separation. He outlined a rational method for calculation of dust separation and emission in complex fuel burning units, in which the dust originates in the furnace, and must pass prior to its emission into the atmosphere, through numerous heat absorbing units, including some in which a measure of dust removal may occur.

He also pointed out what experimental data must be made available to designers before they may fully utilize any method of predetermining the operating characteristics of equipment with respect to cinder and fly ash emission. He attempted a theoretical analysis of the efficiency of dust separation in settling chambers, centrifugal concentrators, and cyclone separators.

H. S. Hersey presented a paper covering the problems of incineration as applied to the disposal of collected wastes of municipalities as well as those resulting from industrial activities, or in connection with apartments and institutions. Because of the transcendant importance of the municipal field, as evidenced by the capital invested and tonnage handled, Mr. Hersey devoted the greater part of his paper to application of incineration, including the history of its development and methods and designs in present use, together with the brief descriptions of some interesting developments not as yet incorporated in any commercial installation.

Forced draft stoker equipment that applies the principle of spreading or throwing slack size coal into a combustion space, part of the fuel burning in suspension and part dropping on to a high resistant type of grate on which the burning is completed, was treated in a paper by J. F. Barkley. Various schemes of throwing the coal and their application to boiler furnaces were shown. The discussion on this paper was spirited by many speakers. Adaptability to any coal, especially those high in moisture and in ash of low fusing temperature was stressed, also flexibility of operation, and low maintenance cost, running down to ½ cent per ton of coal burned. Successful use was cited on all types of boilers even on Scotch marine, developing 160,000 B.t.u. per cu. ft. of furnace volume per hour.

Some troubles with smoking have been overcome by using windboxes with lengthwise division so that one half of the grate can be kept hot while the other half is cleaned. A single grate tends to form blow holes in the thin fire bed when load falls off, resulting in lowered furnace temperature and smoking. Also large combustion chambers are needed and insurance of turbulence by introduction of over-grate air near the grate level or by use of steam jets.

Emission of fly ash from the stack must be safeguarded by baffles, precipitation chambers or a large base to the stack, with no openings that can permit

entry of air into the stack below the breeching entry. Horizontal baffling of boilers seems to give better turbulence and deposit of fly ash than vertical.

Any considerable water wall surface in the furnace is liable to cause lowered furnace temperature at light loads because of the small heat delivered from the thin fire bed and quick response of the fuel feed, with resultant smoke formation.

In his paper dealing with industrial heating and process furnaces, E. J. Holser classified the miscellaneous small types of industrial furnaces into (1) direct heated by combustion of fuel and (2) secondary or indirect heated; he pointed out the wastage of fuel common to many of these furnaces and improvements tending to eliminate or reduce losses; he reviewed developments in new types of indirect process heating; and cited some typical examples of small industrial furnace applications, particularly in the chemical industry. Considerable information was given on indirect heating with Dowtherm.

Condensation of Steam

Developments in prevention of failures of surface condenser tubes in the steam-electric generating stations of The Edison Electric Illuminating Co. of Boston were summarized in considerable detail by R. E. Dillon, G. C. Eaton and H. Peters. In their study of this problem, the authors applied the latest theories of destructive cavitation to show that the inlet-end wastage of tubes in a single-pass condenser is the result of vortices in the inlet water box. The vortices result in destructive cavitation when the water pressure at a point approaches the pressure corresponding to the water temperature, and the cavities in the water are filled with vapor. When the existence condition for the vapor disappears through increase of pressure, the vapor bubbles condense and very high impacts on adjacent surfaces result. Tiny particles are broken from the surface by repeated impacts, making larger and larger pits, and eventually holes through the tubes are produced. Guide vanes installed in the inlet water box of the condenser have effectively prevented vortices from forming.

Discussion of the apparatus and method used in determining the point of condensation in diverging nozzles, which was presented by J. I. Yellott and C. K. Holland, was restricted to nozzles with very short throats and with angles of divergence greater than 2 deg. As a preliminary result of the work described, the authors located the Wilson line for continuously expanding steam at the 4.5 per cent moisture line on the Mollier diagram. Condensation points and sizes of steam droplets were discussed for various pressure and temperature conditions before expansion and for various back pressures.

It was stated that initially saturated steam can in several ways be made to condense at about the 2 per cent moisture condition, which thus becomes the upper limit of the Wilson zone. This type of condensation can be brought about by making the angle of divergence less than 2 deg. or by raising the back pressure to within a few pounds of the initial pressure. Under these conditions the drops grow rapidly and usually achieve a size of the order of magnitude of red light waves as they leave the nozzle. Steam which is initially superheated can be made to produce preliminary condensation only if the throat of the nozzle is very long.

Analysis and Tests on Hydraulic Circuits of Surface Condensers

G. H. Van Hengel illustrated by actual test results, his paper dealing with an analysis of hydraulic circuits of surface condensers. The losses in the tubes, condenser water boxes, and piping were treated in detail. The importance of the weir losses in the outlet box was demonstrated. Tests on condensers with and without a weir showed the actual gain in hydraulic efficiency obtained without a weir. An exact method was given for the calculation of the liberated air in determining the hydraulic-circuit losses. Since the amount of air liberated governs the rate of corrosion of the tubes, this calculation is of considerable importance, especially for salt-water conditions.

According to the author, the losses of a hydraulic circuit can be calculated within an accuracy of 10 per cent. The weir in single-pass condensers, and not the siphon, causes the highest losses and should be eliminated whenever possible. Abrupt changes in direction of flow should be eliminated. The entrance losses due to bellmouthed or ferruled tubes are overestimated.

Power Supply

Pooling of power resources in a large industrial area was discussed by J. W. Parker and R. E. Greene who described the methods followed by the Detroit Edison Co. in providing reserve capacity against the various exigencies of power plant operation and against outages occasioned by routine maintenance and in providing excess capacity to meet the unpredictable and sudden demands of a vigorously expanding industrial community. The experience of this company points out the advantages of combining the use of electricity for large manufacturing with that for small businesses and residences for carrying loads in the order a 1,000,000 kw., present practice is to provide reserve capacity of at least 140,000 kw. distributed between three major generating units.

Flanged Connections

Bolted connections have changed greatly in form during the past 20 yr. with progress in pressure-vessel design and fabrication, as was brought out by E. O. Waters, D. B. Wesstrom, D. B. Rossheim and F. S. G. Williams in their paper presenting formulas for stresses in bolted flanged connections. Whereas flanges were formerly provided with hubs of approximately uniform thickness, screwed to or slipped over the shell or pipe, it is now customary to use tapered hubs, and an integral structure is obtained by butt welding the end of the hub to the shell. This has invalidated former methods of design for flanged connections.

The authors outlined a revised analysis based on the ring, tapered hub and shell being considered as three elastically coupled units loaded by a bolting moment, a hydrostatic pressure or a combination of the two. Design formulas and charts were given for the computation of stresses that are likely to be critical, and their application was illustrated by problems taken from current commercial practice.

Readers' Conference

Louver Furnace Side Wall

To KEEP the cost down is the greatest problem of maintenance. This is true also in the boiler room. In order to gain this point, we were trying all kinds of stunts with the side walls of our boiler settings, which it seemed to us were too short lived. The boilers are operated at about 200 per cent of rating, and this means a rather hot furnace, very hard on the side walls near the fuel bed surface level. Finally we tried the following construction and we are more than pleased with the results.

In order to increase the over-air supply to the fire, we set a row of 18 carborundum bricks on end at about 45 deg. with the line of travel of the grate so as to leave an air space of about 5/32 in. between adjacent bricks. Back of these bricks is an air channel connected to the forced draft system which forces air at about 1.5 in. water pressure through the 5/32 in. openings. This air blast keeps the bricks cool and preserves their life.

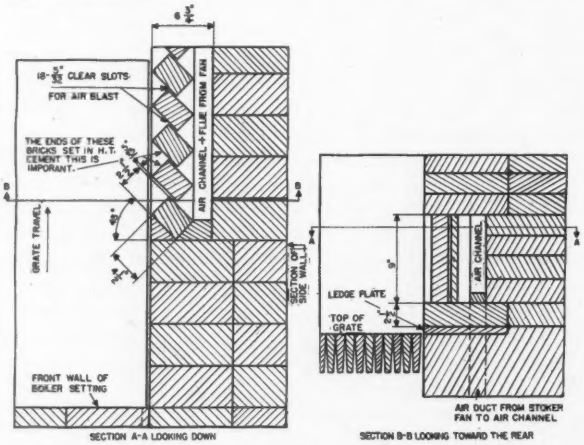

18-5/32" CLEAR SLOTS FOR AIR BLAST
THE ENDS OF THESE BRICKS SET IN H.T. CEMENT THIS IS IMPORANT.
AIR CHANNEL & FLUE FROM FAN
GRATE TRAVEL
SECTION OFF SIDE WALL
FRONT WALL OF BOILER SETTING
SECTION A-A LOOKING DOWN
LEDGE PLATE
TOP OF GRATE
AIR CHANNEL
AIR DUCT FROM STOKER FAN TO AIR CHANNEL
SECTION B-B LOOKING TOWARD THE REAR

Fig. 1. Horizontal and vertical sections of louver furnace side wall

The diagrams show the set-up as it is used on several of our boilers. One change has been made in the later installations, namely that the carborundum bricks have been set directly on the ledge plate, omitting the 2½ in. thick brick on top of the plate. This lowers the 9 in. long air blasts and makes the use of the slice bar easier and is not so likely to damage the air channels or the bricks used to build them. The hot slag is blown off from the top of the openings and it will be noticed that the bricks on top are protecting the openings from the slag flow from above. The slot proper is about 2 in. back of the straight wall above, which makes a very valuable protection of the 5/32 in. slot. It seems that the slag running down the wall from above the louvers is actually blown into the live fire on the grate, and thus disposed of. It is the cooling effect on the walls that adds to the life of the furnace brickwork.

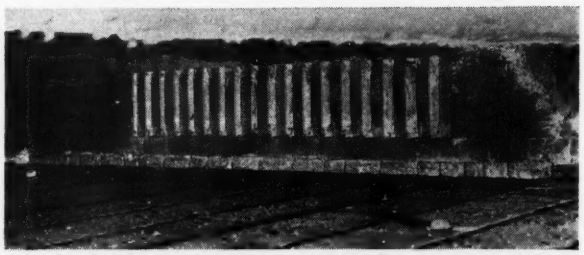


Fig. 2. Furnace side wall built to admit secondary air and cool refractory

This above system of side wall cooling is now used on four 500 hp. boilers with traveling grates, operating at about 200 per cent of rating, using strip mine washed coal screenings. It has cut the side wall maintenance cost to one-half of what it used to be with solid walls.

We believe that with suitable modifications it can be used on any boiler furnace. It is now used, slightly modified, on a sprinkler type stoker fire box.

Moline, Ill. A. C. GRANTZ.

Maximum CO_2 With Natural Gas

I SUBMIT a leaf from my experience in burning natural gas in connection with the flue gas analyses controversy, the previous discussions of which were summarized by J. R. Darnell in the March issue of Power Plant Engineering.

At the plant in question we found that the most efficient point was with a CO_2 of 10.5 per cent burning a natural gas of 1000 B.t.u. per cu. ft. and with a theoretical CO_2 of about 11.5. Roughly I will say that the most efficient point was when the actual CO_2 was one figure below the theoretical and this was about 10 per cent excess air. With this excess air there was either a trace or no CO present. The combustion rate at which the boiler was operated was between 25,000 and 50,000 B.t.u. per cu. ft. per hr.

The furnace of this boiler was not water cooled and there was absolutely no trouble with the refractories. After about 2 yr. of steady operation the furnace walls were apparently in as good condition as when new. At this plant some of the boilers were fired with bulk coal and the average life of the coal fired furnaces was only about six months. The coal was burned with 40 per cent excess air, this being Kansas coal with a heating value of about 10,500 B.t.u. per lb.

In my opinion the failure of furnace refractories is not so much due to temperature as to the slag action. Without the slag action any good grade of refractory will withstand the highest furnace temperatures found in practice. Since there is no slag action with natural gas there should be no refractory trouble even with very little excess air. I would not be surprised but that Henry Cooney is right in his claim that he has

burned natural gas satisfactorily with practically no excess air. While this may not be true as a general rule it might be the best practice under special conditions.

When burning natural gas or any of the other fluid fuels such as oil, pulverized coal, etc., there is a very simple means of determining the minimum of excess air that can be used without the formation of CO. This can be done as follows: Set the draft of the boiler so as to give ample excess air and operate at this setting for at least 5 min. Note the steam output from the flowmeter and also make a notation of the gas pressure at the burners (this is proportional to the gas flow). Then keeping all conditions such as feedwater flow, draft, steam pressure, etc., constant, increase the gas a small increment and note the increase in the steam flow. Operate at this setting for about 5 min. and then increase the gas flow the same small increment, and note again the increase in the steam flow. It should be the same as in the previous case. This is repeated until there is a drop in the increase in steam flow. The excess air at the point when the steam flow increased at a lower rate is the minimum excess air that can be used for best efficiency.

This test can be easily made and can usually be made in less than an hour, so that it shoull be used often as a check. If the steam pressure changes appreciably during the test, it should be discarded and a new test made. I have made these tests hundreds of times and have found them very helpful in efficient operation.

Chicago, Ill. N. T. Pef.

The Psychology of Advancement

The engineering periodicals are filled with articles on how to operate machinery of all kinds, and how to improve efficiency and reduce costs, but no one seems to take time to touch on the technique of personal advancement. How many competent engineers of your acquaintance were born to swear unheard in some dark basement while some man of less ability sat in the swivel chair and issued the instructions? Our hero may have all kinds of thermodynamics at his finger-tips and a head chuck full of power-factors, KVA's and chlorine radicals but lacking that subtle something to put him over the top.

I don't wish to pose as an authority or hold my little two-by-four job up as a shining example, but in 30 yr. working from Harlem to Honolulu I have made a few pertinent observations.

It seems to be a foible of managers to go afield for talent for the executive position. I have known very few men promoted to Chief on the job where they grew up, so to speak. The only promotions I ever got were on steam ships. Any advancements I have had, working ashore, were achieved by dint of shifting my allegience from one company to another.

It takes two things to land a Chief's job: First, find a vacancy—pure luck. Second, a certain amount of salesmanship. A few well-treasured recommendations go a long way. There aren't any rules to go by or any text books to refer to. It's pretty much every man's problem to figure out for himself. A certain well balanced degree of self-confidence helps out if it isn't overdone.

In applying for any kind of job it is good practice to go to the top man first and then work down if you have to.

Stand up till you are told to sit down, but don't fidgit. Answer his questions with confidence and civility, but don't boast or cringe. Either extreme is fatal. Look your man square in the eye, if you can do so without staring. He will be unfavorably impressed if your gaze is shifting.

Never give the impression that you are asking for a favor. Try to give the suggestion that you are offering something of value, but it must be done with enough finesse to avoid a suggestion of boasting.

The prospective customer for your services is human like yourself. It might be worth while to size him up. No two men react in just the same way to a given stimulus. Better than ten to one a little judicious flattery will help if you are smart enough to put it over.

There can be no denying that the ability to land the better job is one of the most important things in an engineer's training, and it is next in importance only to fitting himself to hold the job and is worth the same careful thought and study. I would be interested to hear what some of the older heads have to offer on the subject.

And when you have got your Chief's job—well, that is something else again. If this misses the editorial waste basket I may take that up in some future time.

El Paso, Texas. F. S. Hafford.

Draining a Hurricane

With steam at moderate pressure the velocity of flow in mains generally ranges from about 4000 to 10,000 ft. a min. With high pressures and superheat, much higher velocities are sometimes encountered.

Now 5280 feet is a mile a minute, the speed of an express train. A wind velocity of 60 mi. an hour means a fairly heavy storm, such as is seldom experienced in some parts of the country, although in others, a velocity of 1 to 100 mi. an hour has been reached, but storms approaching this in severity furnish front page news and generally spell loss of life and widespread havoc. A speed of 10,000 ft. per min. is more than 110 mi. an hour, and if we will keep these figures in mind and remember that, disregarding temperature, there is little physical difference between air and dry steam, we shall get a fairly good idea of the kind of thing that is going on inside the average steam main.

As long as the steam is dry and the pressure drop is within allowable limits, velocity has little significance, but when the steam is not dry, and water is being carried along with it, it is well to give consideration to velocity, because water is practically incompressible and a good slug of it traveling at a high rate of speed is quite an effective piece of ammunition.

The undesirability of water in steam mains is generally recognized by operating men, but too often we picture it as a harmless stream flowing quietly along the bottom of the pipe, instead of a mass of water lashed by a hurricane, or as rain driven by a gale.

If we can get a more realistic picture of the actual conditions it will probably save us from several quite

common mistakes, for example, we shall see that except in the case of very low velocities such as are sometimes found in low pressure heating mains, it is impossible to drain a pipe against the steam flow.

A hole in the bottom of a straight pipe connected to a drip is quite ineffectual in getting water out of high velocity steam. This kind of drain may be all right when steam is not flowing, but when it is, it is practically useless, unless we have some effective method of bringing the water to a standstill before we attempt to take it away.

If the direction of steam flow be changed and the water permitted to continue in its original direction, we can draw some of it out, but much of that which is in suspension will be carried with the steam, and it generally requires some kind of a baffle, or better still, a specially designed separator, to get rid of it, care should be taken, however, that slugs of water, traveling at a high velocity, do not strike a dead end such as a "bull head" T, or even a turned-up elbow, otherwise a cracked fitting may result.

If we will only keep in mind the fact that conditions in a steam main are often equivalent to those of a hurricane, we shall be in a better position to deal without our drainage problems in an intelligent manner.

Bloomfield, N. J. JAMES O. G. GIBBONS.

Lighting Off Equipment for Pulverized Coal

HAND TORCHES utilizing some absorbent material soaked in kerosene are almost universally used to start pulverized fuel fires, although the illuminating gas burners or kerosene blast torches generally required to maintain ignition at light loads are sometimes substituted. Simple torches must always be provided, however, to be used in case of mechanical difficulties with these auxiliary burners or failure of the gas supply. While ordinary cotton waste on the end of a rod will do the job, a much more satisfactory torch can be made of asbestos rope, as shown in the sketch. Its advantages are: relatively long life; high oil absorbing capacity with resultant longer burning time; handle bent so that the torch cannot be inadvertently pushed all the way into the furnace; and for the same reason the torch is in the proper position for best ignition when the rod reaches the limit of its forward travel.

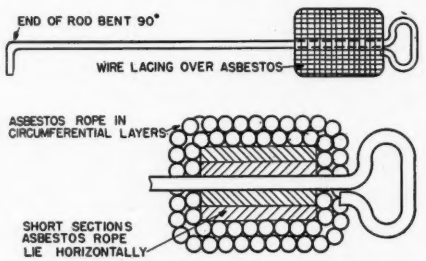
All lighting-off equipment should be carefully maintained and kept in good condition at all times. While this is a matter of ordinary routine when ignition must be frequently established, there are many plants having load characteristics of such a nature that lighting-off is necessary only when placing a boiler in service after outage for repairs or when fires are lost due to some abnormal operating condition. Where this is the case these devices are often neglected and when emergencies do arise it is difficult to restore the fire quickly enough to avoid loss of boiler steam pressure.

After one interruption was experienced in which defective lighting-off devices were a contributing factor, the following inspection procedure was set up in a large industrial power plant to insure against recurrence of the trouble.

1. At least three hand torches in good condition are provided for each boiler. The fireman will note the number and condition of all hand and blast torches on his log sheet at the beginning of every shift and immediately report any discrepancy to his foreman.

2. Kerosene in the torch container of each boiler must be renewed weekly in order to avoid contamination of the oil with water or the evaporation of its more flammable fractions.

3. Adequate supplies of large strike-anywhere matches must be on hand at all times. To guard against any deficiency caused by their unauthorized use or other reason an emergency supply shall be kept in a metal container sealed by the Chief Engineer with a breakable seal. Breaking of this seal must be logged and reported at once so the supply can be replenished.


END OF ROD BENT 90°
WIRE LACING OVER ASBESTOS
ASBESTOS ROPE IN CIRCUMFERENTIAL LAYERS
SHORT SECTIONS ASBESTOS ROPE LIE HORIZONTALLY
Asbestos torch for lighting pulverized coal

4. Whenever the oil blast torch is used it shall be refilled, the burner tip cleaned, and air pressure restored to its proper value.

5. An emergency supply of kerosene (at least 5 gal.) must be kept on the firing floor at all times.

Roanoke, Va. S. H. COLEMAN.

Pulverizer Pete Inspires Mr. Hafford

YOUR ARTICLE by Pulverizer Pete in the April issue gives me an impulse to ride up on the ash hoist with the rest of the gang and throw in my own little shovel full.

When I took over the duties of Chief Engineer in this old hostelry I sold the Manager a lot more confidence than I had left in myself. As an old sea dog I was used to grief in large doses and looking for plenty, wasn't disappointed.

One of the first things I ran a foul of was a three horse power motor hooked up to a centrifugal pump used to circulate brine to various and sundry coils on the floor above. This old motor had been cut over from two phase to three. My predecessor had a fan blowing over it to keep it from burning up, and the whine thereof could be heard in the main dining room above.

I found that the Worthington Big-wig of the town was another old salt, and I appealed to him for council. He agreed with me that one hp. ought to be enough to circulate sufficient brine for our system. According to figures obtainable, that 3 hp. motor should deliver 130 gal. per min. against the 22 lb. friction head indicated by the gage. I had quite a time convincing the big boss that I could save him 90c a day on kilowatt hours with the smaller motor and pump, but he finally gave his consent for the order.

Then the cook got to kicking about the refrigeration and before the new unit arrived I got cold feet. The pump I had ordered was a 1 hp. Worthington, direct-connected brine pump of 3600 r.p.m. It was rated

at about 70 gal. per min. at the same head. But I had already set my course and decided to stand by.

Maybe you can imagine my surprise when I got the new pump set and threw in the switch to see the gage jump up 5 lb. higher than the old one ever did. The answer was that the old pump, while operating at overload rating, was not designed to work at that head and was actually not pumping at anything like capacity. My net gain was $1.00 a day saving in current over the old brine motor, 50c a day in demand charges, and about $1.30 for the four additional hours shut-down for the compressor per day during the peak load hours.

El Paso, Texas. F. S. HAFFORD.

More About Blowoffs for Water Columns

MR. KENNEDY'S article about blow-offs on boilers is satisfactory, as far as it goes, yet the statements made in this article should have been qualified.

The remarks about placing valves in the water column pipes (both in the steam and water connections) should be changed to read "that valves may be installed in these lines, provided they are of the outside screw and yoke type gate valves, and they must also be locked or sealed open." In many instances, valves in lines to gages become a danger if not properly installed, and oft times, if not properly locked open, a person may maliciously close them. Since the majority of states have adopted the A. S. M. E. Boiler Code, this statement is based on it.

When boilers are operated at 150 lb. or less, it is prudent to use brass pipe in the water connections, as this materially assists in preventing incrustation.

When valves are installed in the water column, it is necessary that the location of the steam gage be watched; otherwise if the valve in the steam connection to the water column is closed, an incorrect reading will be shown on the gage.

Regarding a valve in the steam gage line, the boiler code only permits a pet cock so that a person can promptly tell whether or not the cock is open or closed. With a valve on this line a person could not tell at a glance whether or not it was open.

The statements about blowing down the column are in accordance with good boiler practice and should be followed.

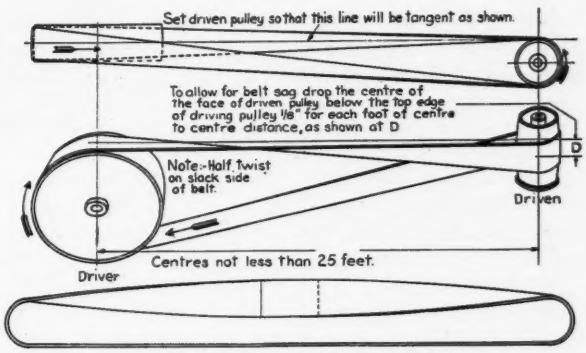
Another point that should have been brought out is that at all right angle turns in water columns, crosses should be used in place of tees or elbows. The water connection pipe should be arranged to drain towards the boiler and the steam connection should be arranged to drain to the column.

Buffalo, N. Y. JOHN J. TIMMONS.

Valuable Quarter-Turn Belt Drive Kinks

THE ACCOMPANYING sketch shows two worth while kinks that are employed and recommended by a prominent builder of deep-well pumps. Their adoption will prove useful to any readers who may some day find themselves confronted by the problem of connecting shafts that are at right angles with each other. In other words, the kinks pertain to "quarter-turn belt drives."

In this particular instance we have a large pulley on a horizontal shaft, and a smaller pulley on a vertical shaft. The relative positions are clearly shown, and, as specified, the belt centers should not be less than 25 ft. In fact the distance should be greater than 25 ft. if the radio of pumps and driver speeds is very large.


Set driven pulley so that this line will be tangent as shown.
To allow for belt sag drop the centre of the face of driven pulley below the top edge of driving pulley 1/8" for each foot of centre to centre distance, as shown at D
D
Note:-Half twist on slack side of belt.
Driven
Centres not less than 25 feet.
Driver

The half twist gives uniform stretch

But to this writer the most interesting and valuable feature is the "half twist" given to the slack side of the belt. By giving the belt a half twist, as shown, the belt will naturally stretch uniformly on both edges and it will be more apt to perform satisfactorily than would be the case if it is not given the half twist. Without such a twist, all of the stretch will be along one edge, and when that stretch becomes permanent, as it usually does, belt trouble is likely to develop.

The other kink is the vertical pulley adjustment recommended for taking care of belt sag, namely 1/8 in. per ft. of center to center distance between shafts.

Newark, N. J. W. F. SCHAPHORST.

Hydraulic Packing Scored by Rust

ANYBODY who has any experience with hydraulic elevators especially the vertical type, knows the work and care required to maintain smooth operation, and that a large part of it depends upon keeping the packing in good condition. Leaky packing on the piston or rods will cause no end of trouble.

In most buildings all cars are operated from the main floor, they start from that point and are landed there. This procedure is continued day after day and at the end of the day the cars are left standing at the main floor landing. About the only time they are run into the pit is when there is occasion for inspection or repairs. When the cars are continually operated from the first floor, the piston and rods are inches short of being at the full length of the stroke or travel with the result that an accumulation of rust and corrosion forms on the top inside part of cylinder and rods that have not been traveled over by the piston.

This rust soon hardens on the cylinder wall, similar to the way carbon forms on the automobile cylinder, at the point where the piston ends its stroke. The real damage to packing is done when the car is finally run down into the pit. It is then that the piston must travel over the rust that has formed on that part of cylinder and ridges are cut in the piston and rod packing.

A good plan would be to run the cars into the pit at the end of each day, this would empty the cylinder

of all water, and at intervals during the day, the car should have a complete run to the pit. In this way the cylinders and rods would be kept free from rust. A well lubricated moving piston will gather no rust.

Philadelphia, Pa. F. G. C.

More About Blow-Offs for Water Columns

OPINIONS of other readers are desired in regard to the location of idler pulleys on belt drives. It is a horizontal drive, 20 ft. between shaft centers, pulleys of same diameter, slack side on top. Should the idler be near the driver or driver pulley?

My experience is that wrapping the driven pulley to prevent slippage gives but very little advantage. With the idler near the driven pulley, as the load comes on, the belt stretches and is slack just as it leaves the driver. If this slack is taken up at the driver there is very little danger of slippage on the driver, even to the load limit of the belt. It is my contention that with the idler near the driver vibrations in the slack side of the running belt are immediately ironed out and a much smoother running belt drive is obtained.

C. L. W.

Selenium vs. Photo-Electric Cells

I beg to refer to the article entitled "Selenium vs. Photoelectric Cells" on page 728 of the December 1936 issue.

The title as well as the contents of "Question and Answer" seem to suggest that there are only two groups of devices which respond to light, the selenium and the photoelectric cell. Please, allow me to point out that the terminology as used in this article is not quite correct and that there is, furthermore, a third group of light sensitive devices which may be of special interest to the party who submitted the "Q. & A."

It seems, first of all, that the term "Photoelectric Cell" is used in this article for the gas or vacuum-filled type of cells, while "Selenium Cell" is used to designate the resistance type of cell. The term "Photo-electric Cell," however, is used for the gas and vacuum-filled type as well as for the resistance type and for the self-generating type which latter cell I wish to bring to your attention by this letter. It has become customary to call the gas or vacuum-filled type "photo-emissive" and the resistance type "photo-conductive." The self-generating type is mostly referred to as "photo-voltaic," the main feature of this type being that they turn light energy directly into electrical energy. They create their own current and do not depend for operation on an external source of electricity.

Now, there are again two types of self-generating cells, the one using copper oxide and the other selenium. The latter cells, due to the use of selenium are sometimes mistaken for the resistance type selenium cells. They have, however, nothing else in common and they make use of an entirely different physical characteristic of selenium. As pointed out before, they do not modulate a current which is passed through them but create current under the influence of light. They are, furthermore, practically free of the time long lag which proved such a severe handicap for the photo-conductive selenium cell.

One feature that they have in common with the resistance type of cells is the fact that they are rugged and do not require any special care and handling. They consist of an iron disc upon which a selenium compound and a protective layer has been deposited.

The best cells of the selenium self-generating type create an e.m.f. up to 0.6 v. and deliver ½ ma. per lumen of incident light.

The three different types of cells together with their characteristics and applications are shown in the accompanying tabulation.

Self-generating cells of the copper oxide type are made by Westinghouse under the name of Photox while self-generating selenium cells are offered by Western under the name of Photronic and by the firm of Electrocell under the trade name of Electrocell.

New York, N. Y. F. LOWENBERG.

PHOTO-ELECTRIC CELLS

TYPE	DESCRIPTION	OPERATION	APPLICATION
1. Photo-Conductive	Discs with selenium as light-sensitive material (some types also using liquids).	Cell modulates *outside* current which is passed through it by changing its resistance under the influence of light. Therefore, also called "resistance type".	This type was the first practical cell and served all photo purposes. It has now been largely replaced by 2 and 3 on account of time lag.
2. Photo-Emissive	Gas or Vacuum-filled glass tubes.	Cell emits current under the influence of light when connected to an *outside* emf. Requires amplifier tubes.	Sound motion pictures, television, photo-actuation (for instance, self-opening doors, etc.).
3. Photo-Voltaic	Discs with light-sensitive layers of copper-oxide (Photox) or selenium compounds (Photronic, Electrocell).	Cell turns light into electricity without the use of any outside source of electrical energy. No amplifier tubes required.	Measuring of light values (light meters, smoke indicators, etc.), photo-actuation (doors, counting, light control, etc.).

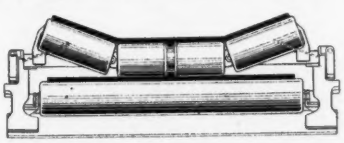
New Equipment

Center-Guide Belt Conveyor

DEVELOPMENT of a center-guide belt conveyor which incorporates new features for guiding long conveyor belts wherever they are used, whether it be in the mine, at the sand and gravel plant, in the power plant, chemical plant, or other production plant, has been announced by Link-Belt Co., Chicago, Ill.

The conveyor is molded with a continuous central guide strip on the underside, and is used on anti-friction conveyor idlers having a central roll with a deep groove within which the guide strip is confined in both runs.

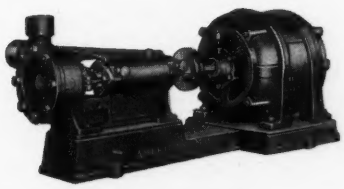
Actual operation has shown that the belt maintains its central carrying position at all times, even when the conveyor is tilted sidewise at a considerable angle, thus making it unnecessary to use side guide idlers. With this position and easy central guiding of the belt, the life of the belt should be materially longer than that of belts which are subjected to destructive edge wear in the process of trying to keep them in line by conventional methods, or of letting them ride from side to side.



This belt, known as the Philips Brand, being named after the Link-Belt engineer inventing the idea, can be furnished of any width, double guides being used with the wider belts.

Turbine Pumps

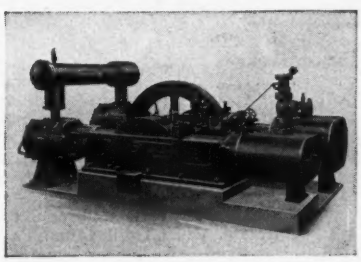
AMERICAN STEAM PUMP CO., Battle Creek, Mich., announces a new American-Marsh turbine pump especially recommended for handling small volumes at high heads. It can be used for pumping water, brines, light oils, gasoline, light syrups, liquid foods, etc., in fact practically any non-viscous liquid free from abrasive



matter. Unlike a centrifugal pump, the Type V Turbine Pump develops a much higher head for any given impeller diameter and speed. American-Marsh Type V turbine pumps are of single-stage construction for pressures up to 175 lb. per sq. in., and in series or two-stage construction for higher pressures. They may be direct driven by motor, steam turbine, or gas engine, or arranged for V or flat belt drive.

Steam-Driven Compressors

DUAL CROSS HEAD DESIGN, tie-rods that maintain all piston strains in exactly the same line with the connecting rod, a uniform flywheel and counter-weighted running gears, are featured in the improved line of horizontal heavy-duty steam-driven compressors offered by Worthington Pump & Mach. Corp., Harrison, N. J.



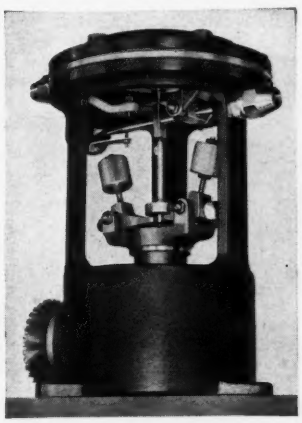
Early cut-off, provided by double-piston steam valves with adjustable riding cut-off valves, results in high steam expansion. The point of cut-off can be controlled either manually or by a governor. The automatic cut-off governor that is provided may be arranged as a speed-and-pressure or variable-speed type.

All bearing surfaces are force-feed lubricated and low oil operating temperatures are assured by a lubricating oil cooler in the line. Duplicate pumping equipment is provided so that each side of the compressor is lubricated independently of the other.

Oil Flow Measurement

IMPROVEMENT in oil flow measurement for control purposes has recently been announced by the Askania Regulator Co. of Chicago, Ill. This is the Askania Oil Transometer, designed to eliminate all errors in oil flow measurement due to changes in viscosity, temperature and specific gravity. The illustration shows the Transometer with the protecting cover removed. The sprocket, by means of a chain from a positive displacement meter, drives the fly-ball governor so that the weights take a position corresponding to the oil flow.

Movement of the fly-ball governor is transmitted to the Askania jet pipe, the receiving nozzle of which is connected to the top of the diaphragm, and, the diaphragm air pressure directly proportioned

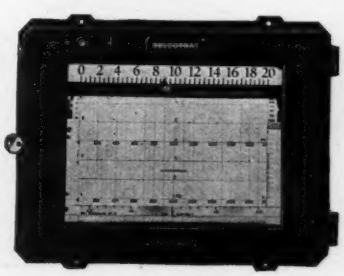


to the centrifugal force of the governor, therefore, varies as the square of the oil flow through the meter.

Slight pressure changes of the air supply entering the jet pipe are said not to affect the accuracy of the instrument which may be used with Askania control equipment as a metering impulse in connection with any oil flow problem.

Photoelectrically Balanced Potentiometer

THE C. J. TAGLIABUE MFG. CO. has announced a new recorder called the celectray. In this radically new type of recorder, a sensitive mirror galvanometer is the primary controlling element in which a beam of light takes the place of the customary metal boom or pointer. The beam of light from the galvanometer in moving on and off a phototube passes the "controlling edge" of a screen thus operating relays which in turn control a reversing motor which drives the moving contact of the Wheatstone bridge or potentiometer. The phototube is not a calibrated element but serves only to detect the direction of the light-beam and bring the galvanometer to zero deflection, according to the well-known null method of balancing an electric

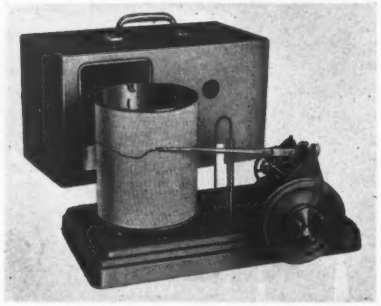


circuit. The new instrument, therefore, is not a "photoelectric potentiometer" in the sense that a balance of photoelectric current is implied.

It is claimed that the new instrument is noteworthy for its extreme simplicity, accuracy and speed, particularly in the multiple point recorders. The average speed of the multiple point instrument is less than 15 seconds per point and the accuracy is guaranteed to 0.1 per cent.

Water Level Recorder

FOR RECORDING water levels in flumes, streams, weirs, etc., Julien P. Friez & Sons, Inc., Baltimore St. and Central Ave., Baltimore, Md., announces a new portable type water level recorder known as the Model FW, 6 by 8 by 12 in. overall and



weighing 10½ lb. A float operates a spined float wheel by means of perforated stainless steel tape and a heart shaped cam guides the pen arm so that equal increments of water always move the pen through the same chart distance. On Model FW-1 curvilinear coordinates are used. On Model FW-2 rectangular coordinates. Except for the pantograph mechanism which provides a vertical pen movement, Model FW-2 is identical with Model FW-1.

Electro-magnetic Feeder

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., is introducing to the mining, metallurgical, chemical and related fields a new type of Feeder to handle ore, rock, or other material that must be fed at a highly uniform rate. This Utah electro-magnetic feeder, new in principle, rugged in construction, was originated by the Utah Copper Company and was developed in cooperation with their engineers. It uses standard alternating current without resorting to expensive auxiliary equipment such as motor generator sets. The entire unit is simplicity itself, having no sliding or rotating parts, no bearings, nothing to lubricate, nothing to wear out, and low in operation and maintenance cost.

The power unit of the Utah electro-magnetic feeder receives its power for operation through a small rectifier mounted on the wall together with a small auto transformer and amplitude speed adjusting switch. It consists of a straight line reciprocating armature mounted between two pole pieces. The rectifier splits the alternating current cycle, one half of the sine wave being sent to one of the pole pieces and the remaining half of the sine wave to the other pole. The armature does not touch the magnets or pole pieces, proper air gaps being provided. There being no contact and no sparking the unit is well adapted for use in explosive atmosphere.

The Utah electro-magnetic feeder may be had in two types, one suspended and the other rubber mounted on the foundation. It can be built in any size or form of deck to suit the application. It can be supplied in types to handle material at high temperatures, in all enclosed types for dusty materials, or in tubular types for special uses. In addition to ordinary feeding and conveying it is an ideal unit for delivering at a substantially uniform rate to crushers, screens, grinding mills, belt conveyors, concentrating equipment, etc. fines and course materials all traveling at the same rate. It is of interest to engineers in all material handling plants.

Small Compressors

INGERSOLL-RAND CO., Phillipsburg, N. J, has announced a new line of fractional horsepower air compressors in ¼ and ½ hp. sizes compact and neat in appearance. They have automatic start and stop control, are equipped with a new style seamless steel tank and an improved check valve.

When furnished for single phase current they are equipped with a brushless capacitor type motor and a built-in automatic protection switch giving overload and under-voltage protection. They are rated for 150 lb. per sq. in. maximum pressure, but may be set for lower pressures, or may be equipped with a reducing valve for still lower pressures.

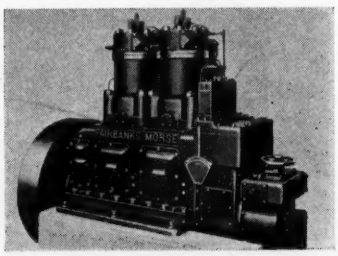
The ¼ and ½ hp. units are available on a 2.4 cu. ft. tank, which is illustrated. This unit is less than 35 in. high. The ½ hp. size is also available on a 4.6 cu. ft. tank in either vertical or horizontal mounting. If desired the units can be furnished less the tank. They are finished in an attractive opalescent brown.

Small Diesel

MODEL 42-E, a new Diesel, has been developed by Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill. to meet the demand of small power users for a heavy-duty, continuous-service stationary engine. It is available in two and three cylinder combinations with ratings of 60 and 90 hp. at 450 r.p.m., and can be furnished for direct-connected, belt or electric generator drive.

With an 8¾-in. bore and 10½-in. stroke, this Diesel is smaller and lighter than the F-M Model 32-E, but it embodies all of the features that have led to the daily use of several hundred thousand horsepower of the larger engines. It is small enough to be installed where space and head room are limited, and it is applicable for any power requirement within its horsepower ratings.

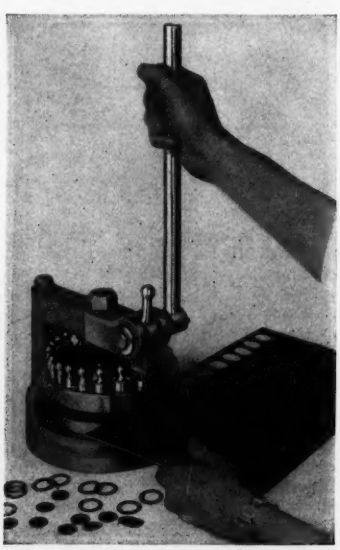
This new model Diesel is characterized by extreme simplicity of design and operation. Two important principles, direct airless injection of fuel and two-cycle design with crankcase scavenging, result in a minimum of moving parts. Cylinder

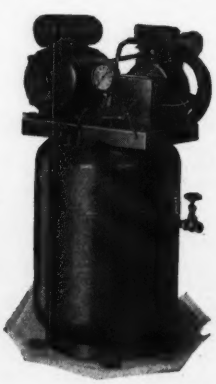


heads are simplified by the elimination of air inlet and exhaust valves with their attendant operating mechanism. All working parts are enclosed, yet are readily accessible for inspection and maintenace. The engines are conservatively rated as to capacity, piston speed and bearing pressures, and will operate continuously at rated capacity with no danger of overheating or of strain.

New Washer Punch

THE NEW WASHER PUNCH illustrated cuts washers out of metal, fabric, gasket material, fibre, steam packing, strawboard, asbestos, leather, felt, cork, rubber, bakelite, mica, and any other similar material up to 1/16 in. thickness; and with only 18 hardened dies, which are furnished





with the machine, it is possible to obtain 150 different washer sizes.

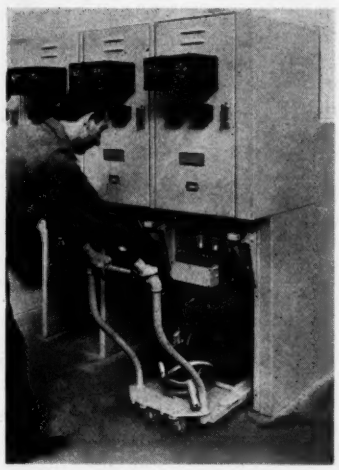
Not only is this die punch of interest to tool plants, but it will be found valuable in all kinds of repair, maintenance, machine shops, experimental departments, and other places where mechanical work is done.

The dies are mounted in an eccentric turret plate, thereby placing them all as close to the edge as possible and making it more convenient to center and withdraw the washers from the machine. The centering system incorporated insures concentric punching. This washer punch is manufactured by the Ideal Commutator Dresser Company, 1033 Park Ave., Sycamore, Ill.

New Industrial Type Metal Clad Switchgear

METAL-CLAD is that class of switchgear characterized by the principle that the oil circuit breaker can be completely disconnected from the bus and line, removed and replaced if desired by a similar breaker.

In the new "RA" 50,000 kv-a., 5 kv. switchgear pictured (part of a fifteen unit installation) the O. C. B. has been lowered by a hand wheel to the truck and is ready

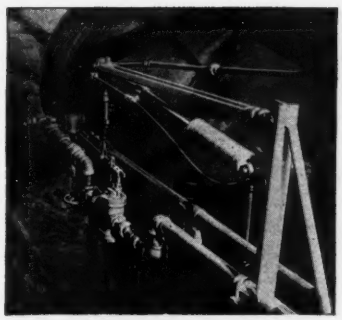


for removal. The lifting and lowering device in the stationary element is a self-contained mechanism which automatically places the O. C. B. in correct position to engage primary and secondary disconnectors. The breaker can be raised or lowered by hand, or with a portable drill-motor. It is a development of the Delta-Star Electric Co., Chicago.

Feedwater Regulator

FEEDWATER LEVEL control made in one size to meet all boiler needs and operate any valve up to 12 in. is announced by J. A. Campbell Co., Long Beach, Cal. Its overall length is 48 in. and it can be operated with or without a whistle or an electric signaling device. The photograph shows the controller mounted on a fire-box boiler. A different mounting is provided for return tubular and water tube boilers.

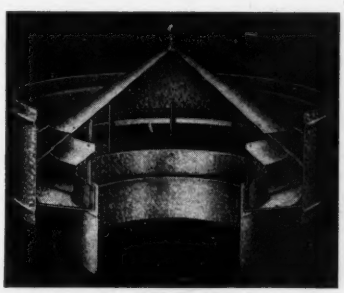
It is called the Campbell-Cantilever boiler feedwater level controller. Changes in water level causes rapid expansion of the inclined tube which is multiplied eight times due to triangular construction.



There are many applications for the controller other than in boiler-feed regulation. It is being successfully adapted to the replacing of steam traps for discharging condensed steam from evaporators and stabilizer reboilers.

Gravity Ventilator

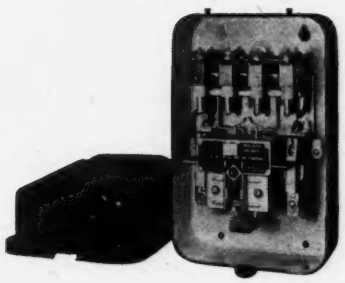
THE BURT MFG. CO., Akron, O., recently announced a line of roof ventilators known as the Standard Gravity. They are designed as a moderately priced unit



with good air moving ability, adaptable to all ordinary ventilating problems. The ventilator is designed to receive either the sliding sleeve, sliding cone, butterfly or louvre damper. It can be constructed of any specified material in sizes from 6 to 96 in.

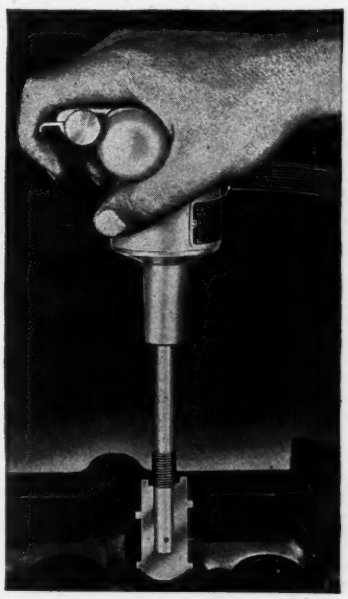
"Ruptor" Equipped Air Motor-Starter

THE ALLIS-CHALMERS Mfg. Co. Condit Works, Boston, Mass., announces a new type of across-the-line air motor-starter, equipped with "Ruptors" known as type AP-7. The "Ruptors" are enclosing chambers which confine and depotentiate the arc formed by circuit interruption. These "arc-depotentiating chambers" greatly increase the interrupting ability of the contacts, and form an isolating barrier between contacts of opposite polarity. Other features include: vertical make and break—Silent operation; enclosed temperature overload relays, affording positive motor protection; unit construction—pole units consisting of individual molded bases mounted on a steel chassis, thus assuring true contact alignment; large silver double break contacts — no contact dressing needed; contacts accessible and quickly renewable; pilot circuit isolated from motor circuit, permitting a separate control voltage for push-button circuit where necessary; motor starter unit arranged for flat surface mounting when applied without enclosure. The starter is furnished for 7½ h.p. at 440 and 550 v., 5 h.p. at 220 v., and 3 h.p. at 110 v



Pneumatic Valve Grinder

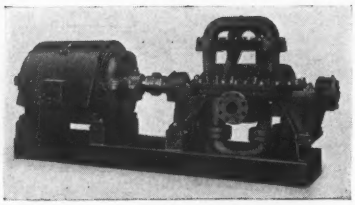
FOR GRINDING the valves in internal combustion engines, or other valves of the poppet and plug type, the Aldon Products Co. of Duncannon, Pa., recently developed a pneumatic valve grinder. The grinder is easily handled, weighs only 28 ounces and has an adjustable speed of from 600 to



6000 strokes per min. The valve is rapidly oscillated back and forth and automatically moves forward one sixth of a revolution at each stroke so as to give a smooth seat free from valleys and high spots. Price of a complete outfit is $12.75 f.o.b. Duncannon.

Boiler Feed Pumps

NEW MULTI-STAGE centrifugal boiler feed pumps for pressures to 1200 lb. per sq. in., is announced by Worthington Pump & Mach. Corp., Harrison, N. J. An even number of impellers, facing in opposite directions, serve to equalize the axial forces and eliminate balancing drums or discs, in addition, large thrust bearings insure long life and reduce maintenance costs. The horizontally-split casing, with suction



and discharge nozzles in the lower half, permits the pump to be taken apart readily for inspection or repair. The pumps are made in 4, 6 and 8 in. sizes for a speed range from 2500 to 4000 r.p.m. Capacities range from 200 to 1500 g.p.m. at pressures up to 1200 pounds.

CORNELL-DUBILIZER CORP. is offering a new line of capacitors for power-factor correction in sizes of 5, 10 and 15 kv-a. for 2300 to 6900 v. In these, a large number of small windings are firmly clamped mechanically between end plates, the whole being encased in a tinned steel container which is filled with Dykanol. The windings are of aluminum foil separated by linen paper, units being insulated from clamps and case by pliable insulation impregnated with Dykanol. Connections of units are in series-parallel groups as may be required to give the desired capacity. Leads are taken out through porcelain insulators of cone type, which set in cork washers.

Stoker Manufacturers to Meet

THE 1937 ANNUAL meeting of the Stoker Manufacturers Association will be held at the Greenbrier Inn, White Sulphur Springs, West Virginia, on June 3, 4 and 5, according to announcement by President Ray C. Goddard. Two of the three days sessions will be devoted to business and joint conferences with coal operators and others in the heating industry interested in the stoker business. The last day will be devoted to the Association's annual golf tournament. The members of the Association will consider and discuss many problems and plans which have been brought to the fore during the past year. The small stoker industry has increased its business to the point where serious consideration will be given to a number of subjects concerning standardization and engineering practice. A feature of this year's meeting will be the presentation of brief papers by representatives of coal operators, boiler and furnace manufacturers and others allied with the stoker industry.

President Goddard stated that all coal operators, railroad traffic officials, heating engineers, boiler and furnace manufacturers and others interested in the stoker industry are invited to attend the business sessions which will be held on Friday, June 4. At this time special consideration will be given to the annual report of the Association's Engineering Committee and also to the research activities of the Association in cooperation with Bituminous Coal Research, Inc., and other research organizations.

Cochrane Corp.

EDGAR S. DAUGHERTY has been appointed by the Cochrane Corp. of Philadelphia as head of the Heater Division of the Water Conditioning and Purification Department. Mr. Daughtery has been with the Cochrane Corp. since 1923, when he joined the company after graduation from John Hopkins University in mechanical engineering, and after three years at Cornell University as instructor and graduate student. From 1923 to 1928 Mr. Daugherty

was in charge of the Cochrane Flow Meter Division. Since 1928 he has specialized in feedwater deaeration, first as technical engineer, then later in a sales engineering capacity.

Utility Adds 11,000 Hp. to Load

FOUR LARGE electric power contracts totalling more than 11,000 hp. in connected load, have recently been obtained by Public Service Electric & Gas Co. from the E. I. duPont de Nemours & Co., the Hudson & Manhattan Railroad Co., Worthington Pump & Machinery Corp. and Swift & Co.

The largest of these contracts is for supplying the full electric power requirements of the duPont company's plastic manufacturing plant in Arlington. The company will abandon its generating plant and use Public Service electric power for all operations. The connected load will total approximately 5000 hp. and it is estimated the consumption of current will exceed 1,000,000 kw-hr. per month. Changeover to Public Service power is expected to be made about July 1.

Public Service power will be used to operate Hudson and Manhattan tube trains on the Newark end of the line when the station is shifted in the near future from Park Place terminal, to the Pennsylvania Station on Market Street, under arrangements recently completed. Approximately 3300 hp. of connected load will be required by the railroad for this service.

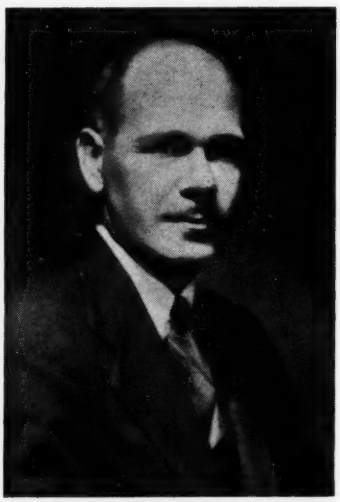
Swift & Co. has contracted to use Public Service power for the operation of a new vegetable oil plant now under construction at Port Newark. Initial installation will amount to 1500 hp. of connected load which will be ultimately increased to 3000 hp.

The Worthington Pump & Machinery Corp. has contracted to use 1300 hp. of connected load for the operation of its new steel plate mill now under construction as an addition to its plant in Harrison.

New President of Elliott Company

JAMES E. WATSON, who has been with Elliott Company for 26 yr. and an active executive for 25 yr., has been elected president of the Company to succeed G. F. Elliott, who has resigned because of time and attention required by his duties as executor and trustee of the estate of his father, W. S. Elliott, founder of the Company, who died Feb. 21, 1935. Since that time G. F. Elliott has been president of the Company and will now serve as Chairman of the Board of Directors and of a newly created Executive Committee.

Mr. Watson joined the Company after graduation from Penn State College in 1911, going to the St. Louis office, whence he was recalled in 1912 to become assistant sales manager. He rose rapidly to sales manager, general sales manager, director, general manager, vice president and, since 1920, has been executive vice-president. Meantime the Company grew rapidly and acquired several plants includ-



ink: Lagonda Mfg. Co., Springfield, O., in 1916; Kerr Turbine Co., Wellsville, N. Y., in 1924; Ridgway Dynamo and Engine Co., Ridgway, Pa., in 1926, the plants at Springfield and Ridgway still being operated in addition to the main plant at Jeannette, Pa., to produce steam specialties, special equipment and most major equipment of a power plant.

LONG SERVICE of an engine is exemplified by the run of a Uniflow engine built by Skinner Engine Co. with nickel-chromium-molybdenum cast iron cylinders and heads, having integrally cast valve seats, for the ferryboat Meadville of Erie Railroad Co. It is rated 4000 hp. with overload capacity of 25 per cent. Its first year of service was 80,000 mi. with no adjustments. Altogether the boat has gone 242,544 mi. with but two minor bearing adjustments and no engine repairs.

SIXTEENTH EXPOSITION of Chemical Industries will be held at Grand Central Palace, New York, December 6 to 11, 1937. Three floors of Grand Central Palace have been reserved and the advance leasing of exhibit space indicates that the 1937 Exposition will be one of the most representative and comprehensive in recent years. Dr. M. C. Whitaker, Vice President of the American Cyanamid Co. and a distinguished figure in the chemical industry will be Chairman of the Advisory Committee.

News from the Field

E. B. SEVERS has returned to active service in the organization of United Engineers & Constructors, Inc., in the Power Engineering Division. Mr. Severs is a graduate of Lafayette College with 30 yr. experience in design, construction, operation, and report work for utilities and industrial concerns. Early experience was with the J. G. White Engineering Corp. and with the Pennsylvania Railroad. He then became associated with the United Gas Improvement Co. and in 1928, when United Engineers & Constructors, Inc., was formed, Mr. Severs continued in charge of important engineering work of the latter organization.

ANNUAL REPORT of Koppers Co. for 1936 shows increases in sales, net income and employment. Rearrangement of financial structure has effected a material reduction in interest and sinking fund requirements; taxes and wage rates have increased and income from investments has shrunk. The name has been changed from Koppers Gas and Coke Co. to Koppers Co. so as better to cover the diversified divisions which now include: Engineering and Construction division, Pittsburgh; Seaboard division, Kearny, N. J.; Brooklyn division, Brooklyn, N. Y.; Minnesota division, St. Paul; Tar and Chemical division, Pittsburgh; Bartlett Hayward and American Hammered Piston Ring divisions, Baltimore; Western Gas division, Ft. Wayne, Ind.

Most advertising and sales promotion is now directed by a new department in Pittsburgh. Group insurance for sickness and accident, financial assistance in emergencies and workmen's compensation are provided, it is stated, exceeding social security and legal requirements. Research and product development, with anticipation of industrial demands, have resulted in new and reconstructed plants and new products. As a consequence, sales have increased in every division.

ALLIS-CHALMERS MFG. Co. has opened an office at 211 North Champion St., Youngstown, Ohio. This office will be in charge of C. H. Legler and will operate as a branch of the Company's Pittsburgh district office of which G. V. Woody is manager.

AMERICAN ENGINEERING Co., Philadelphia, announces the appointment of new representatives to handle its Lo-Hed electric hoists as follows: James B. Barton, Jr., 708 Mortgage Guarantee Bldg., Atlanta, Ga.; F. E. Bennett, 614 N.W. 6th Ave., Portland, Oregon; E. V. Brown, 417 Market Street, San Francisco, Calif.; Geo. R. Douglas, 703 Columbia Mutual Tower, Memphis, Tenn.; Peter H. H. Dunn, 1131 Woodward Bldg., Washington, D. C.; C. G. Forshey, 304 M & M Bldg., Houston, Texas; F. H. Gill, 8113 Colfax Avenue, Chicago, Ill.; Hart Machinery Co., 2513 Fourth Avenue, Tampa, Fla.; L. E. Kenney, 314 Pan-American Bldg., New Orleans, La.; J. A. McCoy, 1436 41st Place, Des Moines, Iowa; Murry-Jacobs Co., 528 First Avenue, S., Seattle, Wash.

TWO LARGE CONTRACTS recently awarded to American Engineering Co. of Philadelphia are for a 175,000 lb. Taylor water-cooled stoker and for water cooling for three Taylor stokers now in service at the Libbey-Owens-Ford Glass Co.'s plant, Toledo, Ohio, the contract being placed by Stone & Webster Engineering Corp.; also an order for three Taylor stokers, each to burn 44,000 lb. of coal an hour for the Delray No. 3 station of Detroit Edison Co. and three additional stokers for that company's Conners Creek Station, this is one of the largest stoker orders recently placed.

"WISE BUYERS are increasing their coal stocks," says A. L. Brown, manager of the marketing division of Appalachian Coals, Inc. "The buyers apparently know that prices will go higher because, under the Guffey-Vinson Coal bill, the commission has the power to fix the price of coal at the mines, which price must be approximately the cost of production. Wage increases provided for in the new 2-yr. contract recently signed by miners and bituminous coal operators will add some $100,000,000 to the selling price of the coal mined. Also no coal can be contracted for a period beyond 30 days or after June 16, until the commission has set the price which will be done about July 1 according to a recent statement from Commissioner C. E. Smith."

M. E. CLARK has been appointed sales manager of Randall Graphite Products Corp. of Chicago. He is a graduate of Oklahoma University in mechanical engineering, a member of the Society of Automotive Engineers, was with the Bunting Brass and Bronze Co. for 11 yr. as field engineer and as manager of the company's branches, and recently was associated with the Drying Systems as assistant engineer in charge of air conditioning.

THE ERNST WATER COLUMN & GAGE Co. has announced the appointment of Boig & Hill, 87 Barclay St. as representative for New York and Connecticut but the company will retain its offices at 342 Madison Ave. under the direction of W. K. Sowdon. For Chicago, the company has appointed Charles B. McBrearty, 6818 East End Ave., and for Louisville the Engineer's Sales & Service, 729 S. First St. has been appointed representative.

YARNALL-WARING Co., Chestnut Hill, Philadelphia, Pa., announces the following appointments in its sales organization: Henry H. Seabrook, Jr., becomes assistant to H. J. Heineman in the Pittsburgh territory; Fred Wetherill joined the Philadelphia sales engineering staff in the impulse steam trap division. The company also announces that it is completing an 80 ft. by 80 ft. extension to its Chestnut Hill plant to provide increased facilities for the manufacture of its steam specialties.

MECHANICAL GOODS DIVISION, United States Rubber Products, Inc., 1790 Broadway, New York City, has announced that effective May 1 J. E. Power, manager mechanical sales New York District, was transferred to 1790 Broadway as assistant sales manager; R. V. Hilands, manager of the Philadelphia and Baltimore districts has been appointed manager, mechanical sales, New York branch; A. B. Means of Philadelphia sales organization has been appointed manager, mechanical sales, Philadelphia and Baltimore; R. F. Jackson of the Baltimore sales organization has been appointed assistant manager, mechanical sales, Baltimore branch; and E. P. Cole of the Denver sales organization has been appointed manager of mechanical sales, Denver Branch.

ANNUAL CONVENTION of the Smoke Prevention Assn. will be held at Stevens Institute, Hoboken, N. J., and Hotel Pennsylvania, New York City, June 1 to 4. Besides inspection trips and business sessions, papers will be presented covering smoke abatement in railroads, steamboats, industrial plants, heating plants and central generating plants, also on reduction of air pollution and on experiences in enforcement of smoke abatement. Sessions on June 1, 3 and 4 will be in New York, those on June 2 at Stevens Institute.

ROBERT H. FERNAULD, Dean of Towne Scientific School, University of Pennsylvania, died at the University Hospital April 24, 1937, from heart trouble. He was 65 yr. of age and had been associated with educational work for almost 44 yr. He conducted investigations for the United States Geological Survey and Bureau of Mines and served as consulting engineer of various official bodies, and was, at one time, consulting engineer of the Pennsylvania Public Service Commission and a member of the Power Survey of Pennsylvania.

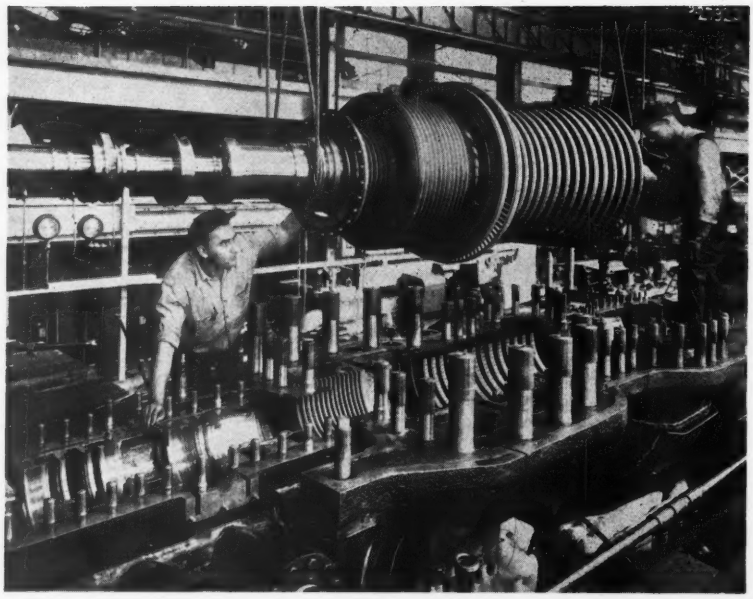
JAMES BONNYMAN, a member of the board of directors of Appalachian Coals, Inc., passed away at his home in Cincinnati, April 9, 1937. Since 1922 he had been president of Blue Diamond Coal Co. He was a member of American Society of Civil Engineers, director of Fifth-Third Union Trust Co., a member of Cincinnati Country Club and of Queen City Club and a communicant of the Holy Angels parish of the Roman Catholic Church.

George W. Reed, vice-president of the Peabody Coal Co. of Chicago, has been elected to fill the vacancy in the board of directors of Appalachian Coals, Inc.

SALE OF Citizens Power & Light Co. of Council Bluffs, Ia., to Nebraska Power Co. has been authorized by the Federal Power Commission, as tending to simplify capital structure and effect operating economies.

Also Central Nebraska Public Power and Irrigation District has been authorized to construct an earth dam about 170 ft. high on the North Platte River 5 mi. above Keystone to form a reservoir extending 25 mi. upstream with storage of 2,000,000 acre ft. and a diversion dam on the Platte River 6 mi. east of No. Platte with a 60-mi. canal on the south side of the river from the diverson dam to Lexington, a number of cross-drainage dams and two regulating reservoirs of 70,000 acre-ft. total capacity with other control works. Three power plants are to be erected along the canal with present capacity of 18,000 kw. each and ultimate capacity of 96,500 hp. Transmission lines of 354 mi. for 115 kv. will connect the plants and to the Platte Valley Power and Irrigation District system to deliver power to Grand Island, Holdredge, Hastings and Lincoln; also a 40-mi., 66 kv. line to Beatrice and 325 mi. of 34.5 kv. lines to distribute to southern Nebraska.

After passing the plants, water will be utilized for irrigation in Gosper, Phelps, Kearney and Adams Counties to the Tri-



Lowering the rotor into the cylinder of the main 49,500 kw. Westinghouse turbine for the Waterside Station of the Consolidated Edison Company, New York City

County district. Or waters can be passed through canals and power plants of the Platte Valley Public Power and Irrigation District.

Power is to be sold to public or private corporations, subject to regulations of the Commission.

Construction must begin by Sept. 1, 1937 and be completed by Aug. 31, 1940. License is to be for a period of 50 yr.

General Motors Forms Diesel Engine Division

FORMATION of a new division to be known as the Diesel Engine Division of General Motors Corp. for the purpose of manufacturing Winton Diesel engines ranging from 20 to 160 hp. for stationary, marine and commercial vehicle use, was announced recently.

The new plant will be located near the intersection of the Pere Marquette railroad and the Outer Drive in Detroit. Facilities for the manufacture of Diesel engine fuel injectors which have been made for several years at the General Motors Research Laboratory will be moved to the new plant and all development and test work for the Winton Engine Manufacturing Co. and the Electromotive Corp. will be carried on here. Heating requirements for the new building will be supplied through an electrically heated boiler using current from the test dynamometers.

Mr. W. T. Crowe has been appointed general manager. Mr. Crowe was born in Detroit in 1893 and graduated from the University of Detroit with the class of 1916. He has had an extensive experience with the Hudson Motor Car Co., the aviation section of the United States Army during the war and with General Motors Corp. From 1920 to 1925 he was chief engineer of the engine division of General Motors of Canada. Following this he went to Germany, played a large part in the redesign and manufacture of the Opel car after the German company was purchased by General Motors. Since 1929 he has been on the staff of O. E. Hunt, vice president of General Motors Corp. in charge of engineering.

A. S. R. E. Meeting

DURING the second week in June, The American Society of Refrigerating Engineers will meet at French Lick, Ind., for the twenty-fourth spring meeting of the Society. In addition to a well rounded social program, there will be three technical sessions; the first on June 8th will be under the general topic of Applications in Agriculture; the second on June 9th, Refrigerated Foods and Transport; and the third on June 10th, Refrigerating Machinery.

Features of Main 50,000 kw. Waterside Turbine

THE OUTSTANDING TURBINE for the Waterside Station of the Consolidated Edison Company is rapidly nearing completion at Westinghouse's South Philadelphia Works. The unit consists of two turbines in tandem driving a single, 53,000-kw., hydrogen-cooled generator at 3600 r.p.m. The main turbine, rated at 49,500 kw., takes steam at 1400 lb. and exhausts into existing 200-lb. headers, which supply several existing turbines. The smaller turbine takes steam from the 200 lb. header and develops a maximum of 3500 kw. Steam from this turbine, extracted at 60 lb., and from the exhaust, 5 lb., is taken to feedwater heaters ahead of the new 1400-lb. boiler. The inlet valves of the large unit are responsive either to speed or to main exhaust pressure; while the inlet valves of the feed-heating turbine are controlled by exhaust pressure, at 5 lb. per sq. in. gage.

This arrangement is indeed an important innovation in power plant engineering. One problem encountered in a superposed application is that of heating the feedwater to the economical point for the increased inlet steam conditions. Many of the older machines for which super-position is desirable do not have suitable openings for extraction of steam for feed heating. To provide such openings involves extensive rebuilding of the older machines at excessive costs, and in some cases such changes are impossible. The feed-heating turbine solves this problem, giving the desired heat balance in a most practical manner.

CURTIS HOTEL in Minneapolis, Minn., after experimenting over a two-year period with its own electric plant, has decided to return to the central station service, effective May 1, and has arranged with The Minneapolis General Electric Co. for the purchase of approximately 1000 hp. in lighting and power service.

COMPRESSED ASBESTOS sheet packing, free of sulphur, known as Prenite 20M, has recently been announced by The B. F. Goodrich Co. to offer increased resistance to oil and such refrigerants as Freon, methyl-chloride and sulphur-dioxide. It is available in 50 by 50 in. sheets, in thicknesses of 1/32, 1/64 and 1/16 in.

For the Engineer's Library

PROCEEDINGS OF THE A. S. T. M., 1936. Published by the American Society for Testing Materials, 260 So. Broad St., Philadelphia, Pa. Size 6 by 9 in. Part I, 1245 pages, Part II 846 pages. Price, each volume, $5.50 paper, $6.00 cloth, $7.00 half leather.

Part I includes reports from 45 standing committees, 115 tentative specifications and test methods covering ferrous and non-ferrous metals, cements, bricks, etc. This section also includes the discussions on the methods of testing, chemical analysis of metals and metallography and in addition all the newly proposed standards issued by the Society for the first time during 1936 and a number of existing specifications which were revised during the year.

Part II in addition to the 11th Edgar Marburg Lecture on Developing American Glass, contains 50 technical papers and discussions. These include symposiums on rubber products, failure of heat treated steel, wire in cables of the Mt. Hope, R. I., Suspension Bridge and a number of papers on the subject of boiler feed water.

ISSUED by Combustion Engineering Co., Inc., New York, a new catalog describes the Type VU steam generator which is of standard construction, complete in sizes ranging from 15,000 to 250,000 lb. of steam per hour and for any steam pressure up to 1000 lb. per sq. in. This is a two-drum unit, fired with pulverized coal, oil or gas, the burners being located in the front of the furnace with tangential admission of secondary air.

THE 1937 Pape-Swift Boiler Reference Book is now ready and may be obtained from the John S. Swift Co., Inc., 105 So. 9th St., St. Louis, Mo., at $1.00 a copy, plus postage. The book is 5x8 in., paper bound and contains 333 pages, with

data on all types of heating boilers. With the book comes a separately bound master index covering the 1934-5-6-7 editions, the four books listing over 900 models of boilers from 80 different manufacturers.

MATHEMATICS FOR THE MILLIONS. By Lancelot Hogben, F.R.S. First American Edition. 648 pages, 197 illustrations, size 6 by 8½ in., cloth. Published by W. W. Norton & Co., Inc., 70 Fifth Ave., New York, N. Y., 1937. Price $3.75.

It is not often that we are privileged to direct attention to a book such as this. Here is a volume that should belong to everybody directly or indirectly connected or associated with the engineering profession no matter what his status; certainly nobody calling himself an engineer should be without it. Whether you are skilled or unskilled in the science of numbers, whether you are interested only in simple arithmetic or in the intricacies of "the" Calculus, you will find this book of absorbing interest. For here, by all the gods, is a book on mathematics that is so outstandingly different from any other book on the subject ever written that it deserves all the praise we can give it. As absorbing as "Gone With the Wind," as instructive as a course in college, in one clean sweep this book presents a complete picture of mathematics from its earliest beginnings to its most recent applications in a way that you will be unable to resist. Not only does it teach the *ways* of mathematics but also the *why*. It shows how mathematics has a vital importance in our future social progress; how it directly affects our welfare in coming years. It gives you its origins; not only does it tell you what logarithms are and what you can do with them, but it tells how they were discovered and by whom; in fact, it presents the entire history. And it does the same for the other branches of mathematical science.

Mr. Hogben, a fellow of the Royal Society, and a professor at the London School of Economics, wrote this book in a hospital during a long illness, for his "own fun." A few friends from among the million or so intelligent people who have been frightened by mathematics while at school persuaded him to publish it. He makes no apology for it; as he says in his "Excuse for Writing It," he wrote it in his capacity as a private citizen interested in education. Whatever objections may be raised against the approach adopted and the views expounded, the book will have fulfilled its aim if it stimulates the interests and removes the inferiority complex of some million people who have given up hope of learning through the usual channels.

The astonishing thing about the book is that it was written for popular consumption. E. T. Bell, a distinguished mathematician, says of it, "The usual course in high school is ample to an understanding of the whole book." For the first time mathematics is treated simply as a language—a language of *size* as apart from a language of sort. It is a book, as H. G. Wells puts it, "that should be read by every intelligent youth from 15 to 90 who is trying to get the hang of things in the universe."

Perhaps the greatest virtue of the book is that Mr. Hogben gives reasons for everything. For instance, where did we get our base number of 10? Count the fingers on your hand (just as men did at the dawn of civilization). Why do we "square" numbers to find areas? Because in the early days square flooring tiles provided a reliable standard of measurement. Why are there 360 degrees in a circle? Because the ancients believed there were 360 days in the year and divided a circle into 360 equal parts to keep track of each day. These are typical of the hundreds of fascinating examples given. In each instance mathematical discoveries are shown to have resulted from the needs of social progress.

We have only one criticism to make and that is that the book lacks an index. This in view of the character of the volume, i. e., the fact that it is more like a novel than a reference or text book is not as serious an omission as it would be in a more conventional book on mathematics.

The book is most encouraging to those who have aspired to the aristocrary of mathematics but found it too difficult. While mathematics is difficult, so is grammar and yet we more or less tactily assume that anybody of reasonable intelligence can master the rules of grammar. This difference in our acceptance of these two sciences (if the latter can be called a science) is the result of our cultural inheritance. To a certain degree we regard mathematics quite within our power of understanding. The common man today constantly solves mathematical problems that tortured the minds of very clever mathematicians in ancient times. This is not according to Mr. Hogben, because we are very clever people, but rather because we inherit a social culture which has suffered the impact of material forces foreign to the intellectual life of the ancient world. The most brilliant intellect at any time is a prisoner within its own social inheritance.

We could write a great deal more about this book but perhaps we have said enough to sell it to you. We could quote what Bertrand Russell, Albert Einstein, Julian Huxley, John Hilton, Harold Laski and others have said about it, but in effect this would only be repeating what we have said here. Buy this book, go hungry for a few weeks if necessary, it will probably do you good, but by all means get this book.

CONNECTING AND TESTING DIRECT CURRENT MACHINES. By F. A. Annett and A. C. Roe. Second edition; 431 pages, size 6 by 6 in., illustrated, cloth. The McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y. 1937. Price $3.00.

This is a practical presentation of the problems arising in the re-connection of direct-current machinery for changes in speed and voltage; with methods of making tests for the locating of faults, and directions for the making of repairs. As pointed out by the authors in the preface, the volume may be considered as consisting of two distinct parts, one dealing with reconnecting direct-current machines for a change in voltage, speed, or both, and the second, locating and remedying faults in direct-current machines. The two sections have been arranged that one may be used independently of the other. Throughout the first part an endeavor has been made to not only give rules and principles that govern the changes made in windings to meet new conditions, but also show how to apply these principles to actual problems of reconnection.

Problems, probably as frequently met with as reconnecting for a change of voltage or speed, are those which involve connecting a series motor into a shunt or vice versa; or figuring a new winding for an old core when no data on the original windings are available. A chapter is devoted to each of these subjects and problems worked out to show how such questions are actually dealt with. In treating the subject of the location of faults in direct-current machines the authors have presented it not only from the practical side and show how the tests are made, but the reasons why the tests are made in the way they are and why certain results may be expected are shown by studies on diagrams of standard windings.

HEAT TRANSFER in Evaporation and Condensation has been reprinted from "Mechanical Engineering" as Reprint No. 10, by the Engineering Experiment Station, University of Illinois, Urbana, Ill. It covers six lectures delivered before various sections of the A.S.M.E. by Max Jakob, a German physicist who for the past few years has been one of the foremost investigators of the properties of steam. The first three lectures are devoted to the problem of condensation, the fourth to the theory of film condensation, the fifth contains experimental proof of the theory and the sixth deviation of the theory and some recent ideas about dropwise condensation. Apparatus used, progress of the work over a period of a number of years, and the results of the investigation by Dr. Jakob and his coworkers are covered in considerable detail. The price is 35 cents.

CONSTRUCTION AND DESIGN of the Loudonville Reservoir Project for the City of Albany is described in a 24-p. booklet written by Benjamin L. Smith of Whitman, Requardt & Smith, consulting engineers, compiled and issued under the direction of Lester W. Herzog, New York State Works Progress Administrator. Copies may be obtained from Information Service, WPA State Headquarters, Old Post Office Bldg., Albany, N. Y.

METAL STATISTICS, 1937. Published by the American Metal Market, 11 John St., New York City. Size 4x6 in. Cloth bound, 588 p. Price $2. In addition to the statistical information on various metals, including prices of production, the thirtieth edition of this book contains numerous new additions and improvements in the nonferrous metals department, particularly zinc, tin and copper. Iron and steel production statistics are based on the American Iron and Steel Institute figures while production statistics on metals are largely based on the U. S. Bureau of Mines and American Bureau of Metal Statistics data.

DISTILLATION ANALYSES of Foreign Crude Oils by Gustav Egloff was reprinted from the Oil and Gas Journal as Book No. 201 by the Universal Oil Products Company, 310 So. Michigan Ave., Chicago, Ill. This is a 48-p. booklet containing typical analyses of some fifty crude oils from all over the world.

INVESTIGATION OF RELATIVE STRESSES in Solid Spur Gears by the Photoelastic Method is the title of Bulletin 288, written by Paul H. Black for the Engineering Experiment Station, University of Illinois, Urbana, Ill. The photoelastic method was used in the investigation which was made to determine stress concentration factors for spur gear teeth, to determine the best location for the keyway, to determine the maximum bore which should be used in a given solid gear. A limited number of copies are available for free distribution. The regular price of the bulletin is 40 cents.

MACHINE SHOP OPERATIONS. By J. W. Barrett. Published by American Technical Society, Drexel Ave. at 58th St., Chicago, Ill. Size 8½ x 11 in. 850 pp., flexible fabricoid binding. Price $5. For the power plant man, who is not a machinist and yet must occasionally do machine work, or, for the chief engineer or superintendent who must supervise maintenance and repair machining operations at irregular intervals, this book is unusually valuable. It covers 280 actual jobs involving lathe, milling machine, slotter, horizontal boring mill, shaper, drill press, planer and vertical boring mill. In addition, the first section of

the book covers the use and proper applications of measuring tools, bench work and layout work. All of these sheets give detailed directions for the use of the instruments and tools such as scales, combination square, gauges, dividers, calipers, dial and test indicators, micrometers and Johansson blocks.

Each machine job is covered by a separate job ticket described in detail by text and illustrations and giving the proper method of procedure. Some typical job tickets selected at random cover babbitting, babbitting solid bearings in place, pressing a gear on a shaft, cutting keyways and fitting keys, fitting crank brasses, assembling a large centrifugal pump, machining a connecting rod end, cutting a machine steel internal gear, machining a cast steel rotor, machining a cast iron valve operating stand, machining a cast iron cylinder head, machining a forged steel shaft, grinding centers, sharpening drills.

In addition to their practical use, the job tickets are arranged for individual self-study work and apprenticeship training classes. They are bound in a screw post binder and the sections may be removed for individual use among a number of students.

BIG BUSINESS; ITS GROWTH AND ITS PLACE. 102 pages, 6 by 8 in. Cloth, $1.35. Twentieth Century Fund, Inc., 330 W. 42nd St., New York City.

In a series of three studies, it is planned to outline the place of big business, its profits, its salaries; and to follow these by formulating a program of action to meet whatever problems may be revealed by the study. The present volume embodies the results of the first study and is purely a presentation of facts. Research was directed by Rufus S. Tucker, editing was by Alfred L. Bernheim, while the whole series is in charge of a special committee headed by Ralph E. Flanders.

This first volume attempts to show the place that big business and large corporations occupy in the industrial activities of the country in comparison with smaller corporations, partnerships and individually owned concerns. Presentation is by charts, tables and a discussion of business activities. To give a standard, a "big business" corporation has been taken as one whose assets are $50,000,000 or more, or whose annual income is $5,000,000 or more, the two not being necessarily simultaneous. As to employes, corporations with more than 1000 employes are considered large.

The study reveals that development of large corporations varies greatly with the nature of the business and precedent, as, for instance, in cigarette manufacture 99 per cent of wage earners are employed by the eight largest concerns and 91 per cent by the four largest; while in women's clothing, less than 14 per cent of workers are employed by the six largest organizations and only 2 per cent in the four largest. Of total economic activity, only 57 per cent is incorporated, the balance being carried on by individuals and partnerships, but among corporations, 594 of the largest, or 3/20 of 1 per cent of the total number owned, in 1933, 53 per cent of the total assets of all corporations and, for 82 industries, the 512 largest organizations, or 1.6 per cent of the total number, employed 37 per cent of all the wage earners in these industries.

THE A.S.H.V.E. Guide, 1937, published by The American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York City. Price $5. 6 by 9 in., 44 chapters, 808 pages of technical data, 316 pages of catalog data.

No more valuable reference book to the heating and ventilating engineer is published than the Guide which has been issued annually for the past 15 yr. This year an added feature is a new Bulkeley Psychrometric Chart, size 16 by 20, with an additional directrix line. In this new edition the chart is enclosed in an envelope attached to the inside back cover. Other new features of the Guide include a new chapter written on the physical and physiological principles of air conditioning; the data for properties of dry and saturated air have been recalculated and tabulated, based on the instantaneous specific heats of air; a new table has been added giving the time, mean and instantaneous specific heats of air over a wide range of temperature; the tables of heat transmission coefficients have been amplified; problems of humidification, dehumidification and water cooling are discussed in a rewritten chapter; a new chapter on automatic control is presented in this edition; the new chapter on sound control presents the subject material in a manner suitable for interpretation by heating and air conditioning engineers; the chapter on air distribution has been completely rewritten. The entire work has been revised and simplified with new material bringing the Guide strictly up to 1937 conditions and with the complete index, the Guide is a very definite help to designers and users of heating and ventilating equipment.

THE SIMPLE AND DIRECT ANSWER to All Problems of Heat Transfer in Boilers, by Loyd R. Stowe. 8½ by 11 in., 90 pages, paper bound. Published by Stobond, 719 Linden Ave., Wilmette, Ill. Price $3.

This book is intended by the author to fill the need of engineers for an elementary treatise on the subject of heat transfer from furnace gases to the water in the water walls, boiler tubes, to steam in the superheaters and to air in the preheaters. The author has developed a sound logic, free of intricate formulas from which most questions on the subject of heat transfer in boilers can be satisfactorily answered. It is the author's contention that from the standpoint of efficient heat transfer, a boiler can be designed from the facts developed within this book which is evidence of the tangible and comprehensive nature of the treatise. The book was made possible by the author's analysis of data from about 500 boiler tests conducted on a pair of twin boilers. In addition to this considerable data has been accumulated on heat absorption in water walls. He has also made use of data secured by Professor De Baufre while he was associated with the Combustion Engineering Co., these data being selected because of great skill and accuracy employed in securing them which their analysis reveals.

FAIRBANKS, MORSE & CO., 900 S. Wabash Ave., Chicago, have recently issued three new bulletins on pumps: No. 5814 F describes the company's ball bearing centrifugal pump especially designed to fit the requirements of and approved by the National Board of Fire Underwriters and the Associated Factory Mutual Fire Insurance Companies; No. 5870 describes ball bearing centrifugal pumps for operation at high speeds against heads up to 245 ft. and capacities from 90 to 225 g.p.m.; Bulletin 6150 describes simplex self-oiling power pumps for water, oil and similar liquids, for pressures up to 300 lb. per sq. in., and quantities of up to 29 g.p.m.

LINK-BELT CO., 307 N. Michigan Ave., Chicago, Ill., has issued an illustrated folder No. 1435 which deals with the new Super Salem steel elevator bucket recently placed on the market by this company.

QUIGLEY CO., INC., 56 W. 45th St., New York City, in its Bulletin No. 327 gives considerable information on a new development in plastic refractory lagging for temperatures up to 2200 deg. F. This material is known as Insulag.

FOR TESTING and rating steam unit heaters, a standard code has been prepared by the joint committee of the Industrial Unit Heater Association and the American Society of Heating & Ventilating Engineers. Copies may be obtained from the Industrial Unit Heater Association, 5-208 General Motors Bldg., Detroit, Mich.

ROOTS-CONNERSVILLE BLOWER CORP., Connersville, Ind., has just issued a new bulletin, 260-B13B, describing its line of shallow well water systems. These systems incorporate the Type T turbine pump with automatic control and cover a range of sizes from 300 to 4200 g.p.h.

STICKLE STEAM SPECIALTIES CO., Indianapolis, Ind., has recently published a series of folders dealing with their various types of steam traps, these being Stickle No. 50 steam trap, the series AE Stickle steam trap, and the Stickle thermostatic vacuum trap designated as Series T.

SUPER THERMO-STUCCO, a new refractory development of the Chicago Fire Brick Co., 1467 Elston Ave., Chicago, Ill., is made the subject of a bulletin recently issued by the company. This new product is for use in boiler furnaces, drop forge furnaces and billet furnaces as well as other types of furnaces used in industry. It offers a means of cutting air infiltration and heat losses and of lowering costs of refractory upkeep.

CATALOG No. 3005, recently issued by The Brown Instrument Co., Philadelphia, Pa., covers the complete line of Brown indicating and recording CO_2 meters, as well as the combined CO_2 and flue gas temperature recorders. It also contains a schematic diagram illustrating the operating principle of the Brown CO_2 meter and describes the passage of the flue gas through the various units.

THE AMERICAN BRASS CO., American Metal Hose Branch, Waterbury, Conn., has issued its bulletin SS-3 dealing with American seamless flexible metal tubing, giving the essentials of construction, advantages, applications, typical installations and includes many photographs illustrating the use of this product in industry.

TECHNICAL information on monel, nickel and nickel alloys is given in Bulletin T-12 recently published by the Development and Research Division of The International Nickel Co., Inc., 67 Wall St., New York City. Such information as stock for machining, tool design, tool steel, cutting compounds, cutting-off operations, turning and boring, drilling, reaming, tapping, lathe threading and precision grinding are given in some detail.

SPRAY NOZZLES for air conditioning and for general industrial uses are made the subject of a new bulletin designated as N-615 by Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa. The design of the nozzle is of the involute type and the bulletin cites typical uses for various designs used in industry. It also gives curves showing capacities and characteristics of the spray.

BULLETIN L-6 on Elliott generators and motors, distributed by Elliott Co., Jeannette, Pa., gives in its 24 pages numerous illustrations of all types and sizes as applied in various plants for all sorts of uses.

OIL TANKERS Mobiloil and Mobilgas built by Sun Shipbuilding and Dry Dock Co. for the Socony-Vacuum Oil Co., and powered by De Laval steam turbines are described and illustrated in a folder issued by De Laval Steam Turbine Co., Trenton, N. J. Steam is supplied at 400 lb. and 700 deg. F., a shaft horsepower-hour being developed for 0.6 lb. bunker oil for all purposes.

FRICK Co., Waynesboro, Pa., has recently issued two new bulletins; No. 182-A a graphic description of refrigeration for the oil industry; and Bulletin 516-A, ammonia booster compressors for low temperature refrigeration.

FLEXURAL VIBRATIONS of Piezo-Electric Quartz Bars & Plates is the subject of Bulletin No. 291 issued by the Engineering Experiment Station of the University of Illinois, dated March 15, 1937. This bulletin by J. Tykocinski Tykociner and Marion W. Woodruff describes methods of cutting and preparing quartz bars and plates for use in low frequency stabilized oscillators and fitters.

CONSTRUCTION SERVICE is the title of a well illustrated twelve page bulletin (No. 602), picturing a few of the company's construction activities, just issued by the Pittsburgh-Des Moines Steel Co., 3456 Neville Island, Pittsburgh, Pa. Such construction projects as pipe lines, station piping, equipment installations, water treating plants, refuse incinerators, and sewage disposal plants are shown in pictures.

COVERING their complete line of millivoltmeter pyrometers, indicating, recording and controlling types, together with accessories such as moisture-proof rotary switch, multiple key type switch, control relays, valve mechanisms and thermocouples, a new catalog No. 15C has just been released by The Brown Instrument Co., Philadelphia, Pa.

NEW CATALOG SECTIONS describing standards and fittings have been announced as additions to the Westinghouse Street Lighting Equipment Catalog. These sections include descriptions of cast iron standards, Hollowspun Granite standards, Union Metal steel standards, top sections and castings for standards, brackets and equipment for poles, ornamental crooks. Copies of any of the catalog sections may be obtained from the Lighting Division, Westinghouse Electric and Manufacturing Company, Cleveland, Ohio.

"ELECTRIC HEATING UNITS AND DEVICES" is the title of a new 60 page bulletin (No. GED-650) recently issued by the General Electric Co., Schenectady, N. Y. This bulletin lists numerous small heating units of all kinds for a multitude of tasks. Methods of manufacture are shown and useful data for determining power requirements is included.

A PUBLICATION describing the Westinghouse cycle counter has been recently announced. This counter indicates definitely the time of operation of any apparatus which will or can be arranged to open or close an a.c. circuit of known frequency. The catalog describes the applications, construction and operation of this instrument. Circuit diagrams are also included. Copies of the catalog are available from the nearest district office or direct from Department 5-N, Westinghouse Electric and Mfg. Co., East Pittsburgh, Pennsylvania.

INGERSOLL-RAND Co., 11 Broadway, New York, N. Y., has just issued a new catalog describing its Cameron Motorpumps, compact machines combining electric motor and centrifugal pumps in a single unit with capacities ranging from 5 to 1000 g.p.m. for heads to 500 ft. Motor sizes range from ¼ to 40 hp.

ALLIS-CHALMERS MFG. Co., Milwaukee, Wis., has issued a new eight-page attractive leaflet 2254 entitled "Behind the Nameplate" devoted to the features of large Allis-Chalmers circular coil shell-type power transformers as well as voltage and phase angle regulating equipment and which includes many recent installation pictures.

A CATALOG describing many types of industrial lighting equipment for use with 200 and 400 watt high intensity mercury vapor lamps has been published by the Westinghouse Electric and Mfg. Co. Combination mercury-incandescent units are also described. Included in the catalog is information on designing an installation, choosing mounting heights, spacing and size of units, for different wall and ceiling conditions, and average resultant lighting intensity.

USE OF AN ELBOW in a Pipe Line for Determining the Rate of Flow in the Pipe is the result of experimental work by Wallace M. Lansford and is published as Bulletin 289 by the Engineering Experiment Station, University of Illinois, Urbana, Ill. The regular price of this volume is 40c but a number of copies are available for free distribution.

The tests showed that an ordinary commercial 90 deg. elbow may be used successfully as a flow meter. For accurate results the elbow should be calibrated in an actual service location but for cases where this cannot be done the bulletin presents curves and data which make it possible to select values which may be used in an ordinary case with an error of less than 10 per cent. The investigation covered elbows ranging from 1 to 24 in. and included 16 different elbows tested in nearly forty different positions and locations in various pipe lines.

SAVINGS WITH INSULATING REFRACTORIES by J. G. Coutant, consulting engineer, is being distributed by Quigley Co., New York City. It discusses the effect of such products as light weight Insuline and high temperature Insulbrix.

A PUBLICATION describing the new line of Type CS Squirrel-Cage Motors has recently been announced by the Westinghouse Electric and Mfg. Co. These motors employ a new heat exchanger principle of cooling, self-cleaning ball bearings, tested insulation with taped end turns and corrosion resisting construction for general use indoor or outdoor where foreign matter would be harmful to the windings.

METALASTIC PACKINGS is the title of an extremely interesting bulletin recently issued by the Metalastic Manufacturing Corp., Hackensack, N. J., which describes this type of packing both by word and pictures and tells about the outstanding successes of Metalastic since the organization of the company in 1922. Information is given on coil packing, how to pack high pressure steam heating valves, water faucets, swing joints, gasoline generating lamps and refrigerating equipment.

IN ITS BULLETIN NO. 264, the Nash Engineering Co., South Norwalk, Conn., gives a very interesting description of the Jennings Manifold type vacuum heating pump and engineering data pertaining to the selection of equipment and its installation.

BULLETIN 1500 pertaining to Megger instruments for measuring ground resistance, has recently been issued by James G. Biddle Co., 1211 Arch St., Philadelphia, Pa.

These instruments for ground testing are for measuring resistance to earth of ground connections and are *not* intended, for measuring insulation resistance of insulation grounds.

CAPACITORS of box type made by Cornell-Dubilier Corp. are described in a folder recently issued from So. Plainfield, N. J.

RECORDERS for humidity and temperature are illustrated and described in a folder issued by Julien P. Friez & Sons, Inc., Baltimore, Md.

BULLETIN 164, issued by the Morris Machine Works, Baldwinsville, New York, on double-suction horizontally-split centrifugal pumps describes a design which has developed high efficiencies over wide ranges of capacities. The bulletin concisely outlines the features of impellers and casings; the steady and thrust bearings; stuffing boxes; machining and finishing processes.

ELLIOTT Co. has just published the first two bulletins in a series covering a new line of electric heaters and heating equipment for the process industries. Bulletin M-1 covers indirect electric systems for industrial heating by hot circulating oil, using high temperature vapor, special immersion type heaters for large scale operations in existing stills, and special tubular heaters built for obtaining temperatures up to 2000 deg. F. and pressures of 1500 lb. or more. Bulletin M-2 covers the Elliott continuous deodorizing system for edible and industrial oils, using electric heaters.

IN A PAMPHLET designated as Francke Bulletin No. 53, the John Waldron Corp. of New Brunswick, N. J., describes a new fractional horsepower flexible coupling which is made entirely of steel and recommended for fans, fuel pumps, generators, etc., up to ¾ hp. at 1800 r.p.m. and shafts up to ¾ in. diameter.

GEO. P. REINTJES Co., 2517 Jefferson St., Kansas City, Mo., announces the development of a simplified arch construction which requires fewer shapes of tile and castings, is flexible in application, has freedom of expansion, and is universally applicable to any existing arch steel work. This construction is illustrated in Bulletin No. 201 recently issued.

WARD LEONARD ELECTRIC Co., Mount Vernon, N. Y., has just released Bulletin 131 on Magnetic Relays. This Bulletin lists more than 100 relays for Heavy Duty (1 to 25 amp.) on d.c. and a.c. circuits. These relays are particularly adapted for transfer purposes. The bulletin gives valuable coil and contact data, contact arrangements, dimensions and enclosures.

Power Plant Construction News

Calif., Los Angeles—Aluminum Co. of America, Inc., Gulf Building, Pittsburgh, Pa., plans installation of electric power equipment in new branch plant at Magnolia Street and Fruitland Avenue, Vernon, Los Angeles, where tract of land has been acquired, comprising three main units. Entire project will cost over $250,000. J. A. Schreiber is chief engineer, first noted address.

Colo., Denver—Bureau of Reclamation, Customhouse, Denver, will receive bids until June 7 for two vertical shaft 115,000-hp. hydraulic turbines, and two turbines and governors with pumping equipment for regulating speed of such units, for installation in Boulder Canyon Project, Arizona-California-Nevada. Equipment will be installed by Government (Specifications 734). Also, until June 14 for two 82,500-kva. vertical a.c. generator units for same project (Specifications 732).

Conn., Stamford — Pitney-Bowes Postage Meter Co., Pacific Street, plans installation of electric power equipment in new three-story addition to plant, for which superstructure will be placed under way at once. Entire project will cost over $100,000. Howard Chapman, Stamford, is architect.

Conn., West Haven — Armstrong Rubber Co., plans installation of power equipment in new three-story addition to automobile tire-manufacturing plant. Entire project will cost close to $75,000. Fletcher-Thompson, Inc., 1336 Fairfield Avenue, Bridgeport, Conn., is architect and engineer.

Fla., Jacksonville—Board of City Commissioners, City Hall, has plans maturing for extensions and improvements in municipal electric light and power plant, including installation of additional equipment. Financing in amount of $1,250,000 for project is being completed. Taylor Engineering Co., Jacksonville, is consulting engineer.

Ind., Vevay—Town Council is considering early rebuilding of municipal electric power plant, damaged by recent flood, including installation of new equipment. No official estimate of loss has been announced.

Iowa, Hampton—Franklin County Rural Electric Co-operative, Inc., Hampton, plans steam-electric generating plant for power service for new rural electric distributing system. Financing has been arranged through Federal aid. Buell & Winter Engineering Co., Insurance Exchange Building, Sioux City, Iowa, is consulting engineer.

Iowa, Webster City—City Council is considering extensions and improvements in municipal electric power station, including installation of a new 2000-kw. generating unit and auxiliary equipment. Cost estimate close to $100,000. H. E. Risner is superintendent at plant.

Ky., Louisville—Seagram Distillers Corporation, 405 Lexington Avenue, New York, plans installation of electric power equipment in new addition to distillery on Seventh Street Road, Louisville, to be equipped primarily for a mechanical-bottling unit. Entire project will cost close to $1,000,000.

La., Mobile — Ozark Corporation, Helena, Ark., plans installation of electric power equipment in new plywood mill at Navco Station, Mobile, where site has been selected. Plant will comprise several one-story units; a boiler house will be built. Entire project will cost close to $200,000. Company is affiliated with American-Mexican Corporation, Navco Station.

Mass., Boston—Edison Electric Illuminating Co., 182 Tremont Street, has plans maturing for new addition to steam-electric power plant on L Street, South Boston. Additional equipment will be installed for considerable increase in present capacity. Cost close to $1,000,000. Jackson & Moreland, 31 St. James Avenue, Boston, are consulting engineers.

Mich., Riverview—Firestone Tire & Rubber Co., Akron, Ohio, plans installation of electric power equipment in new mill at Riverview, near Wyandotte, where tract of 100 acres of land recently was acquired. Entire project will cost over $350,000.

Mo., Kansas City—General Box Co., 1600 West Eighth Street, plans installation of electric power equipment in one-story addition to corrugated box-manufacturing plant, 110x200 ft., on which work will begin soon. Entire project will cost over $85,000. Eugene Schneider, 2107 Grand Avenue, is architect.

Neb., Fremont — Board of Public Works, E. M. Hill, secretary, has plans under way for extensions and improvements in municipal electric light and power plant, including installation of new equipment. Cost about $300,000. Financing is being arranged through Federal grant and loan. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

Neb., Stamford—Beaver-Sappa Public Power & Irrigation District, Stamford, L. B. Carraher, secretary, plans two hydroelectric power developments in connection with power and irrigation project, with generating stations to be located on Sappa and Beaver Creeks, respectively. A transmission system will be built and series of electric-operated pumping stations. Entire project will cost about $2,600,000. Financing will be arranged through a Federal loan and grant. William R. Martin, Stamford, is consulting engineer for project.

N. J., Elizabeth—Gar Wood Industries, Inc., 7924 Riopelle Street, Detroit, Mich., plans installation of electric power equipment in new branch plant at North Avenue and Meadow Street, Elizabeth, where tract of over 4 acres of land has been acquired, for manufacture of oil burners and air-conditioning equipment. Entire project will cost over $100,000.

N. Y., Dresden—New York State Electric & Gas Corporation, Ithaca, N. Y., is completing plans for new steam-operated electric power plant at Dresden, where site has been secured on Lake Seneca, to be equipped for an initial capacity of 20,000 kw., with ultimate output about 40,000 kw. in future. A power substation and switching station will be built, and extensions made in transmission lines in that area. Fund of $2,300,000 is being arranged for project.

N. Y., Syracuse—L. C. Smith & Corona Typewriters, Inc., 701 East Washington Street, plans installation of electric power equipment in new six-story top addition to present two-story plant unit, for which superstructure will proceed at once. Entire project will cost in excess of $100,000.

Ohio, Cleveland — Municipal Light and Power Department, City Hall, has tentative plans under consideration for new municipal electric power station in connection with new water filtration plant at St. Clair Avenue N. E., and Chardon Road, on which work is now being placed under way. Proposed power station will have an initial capacity of 50,000 kw., and will be used in conjunction with pumping plant at filtration works, latter to have a rated capacity of 200,000,000 gal. of water daily.

Ohio, Dayton—Pittsburgh Plate Glass Co., Grant Building, Pittsburgh, Pa., Paint Division, plans installation of electric power equipment in new addition to plant of Thresher Varnish Co., Dayton, recently acquired and to be operated as a subsidiary interest in future. Entire project will cost close to $400,000.

Okla., Guymon—General Atlas Carbon Co., 60 Wall Street, New York., plans power house, compressor station and other mechanical operating units at new carbon black manufacturing plant near Guymon, to be equipped to process about 5,000,000 cu. ft. of natural gas daily. Application has been made for permission to construct plant. Cost over $100,000. Company is a subsidiary of Cities Service Co., first noted address.

Pa., Port Allegany—Pittsburgh-Corning Corporation, care of Pittsburgh Plate Glass Co., Grant Building, Pittsburgh, Pa., recently organized as a joint interest of last noted company and Corning Glass Works, Corning, N. Y., plans installation of power equipment in new plant for manufacture of structural glass products at Port Allegany, where site has been secured. Initial works will total about 100,000 sq. ft. of floor space. Entire project will cost in excess of $600,000. H. S. Wherrett, head of Pittsburgh Plate Glass Co., is president of new company.

Tenn., Elizabethton—North American Rayon Corporation has approved plans for new addition to power house at local mill, including installation of equipment for increased capacity, and will begin work on project soon. Main offices of company are at 261 Fifth Avenue, New York, N. Y.

Tex., Houston — "Houston-Chronicle," Travis Street, plans installation of electric power equipment in four-story and basement addition to printing and publishing plant; an air-conditioning system will be installed, as well as conveyors and other mechanical-handling equipment. Entire project will cost over $600,000. A. C. Finn is architect, and Robert J. Cummins, consulting engineer, both Bankers' Mortgage Building, Houston.

Va., Covington—City Council has tentative plans under consideration for new municipal electric power plant, estimated to cost about $400,000. Application has been made for a Federal grant of $181,636, and other financing will be arranged to make gross sum noted.

Va., Radford—Burlington Mills Corporation, Jefferson Standard Building, Greensboro, N. C., plans installation of electric power equipment in new silk mill at Radford, where tract of about 11 acres of land has been acquired. A boiler house will be built for mill service. Entire project is reported to cost close to $100,000.